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THE American Society of Agricultural Engineers was organized in December, 1907, at the University of Wisconsin by a group of instructors in agricultural engineering from several state agricultural colleges, who felt the need of an organization for the exchange of ideas and otherwise to promote the advancement of agricultural engineering. The object of the Society, as defined by the Constitution, is "to promote the art and science of engineering as applied to agriculture, the principal means of which shall be the holding of meetings for the presentation and discussion of professional papers and social intercourse, and the general dissemination of information by the publication and distribution of its papers, discussions, etc."

The membership of the Society represents all phases of agricultural engineering, including the educational, professional, industrial, and commercial fields.

The scope of the Society's activities embraces both the technical and economic phases of the application of engineering to agriculture, and is comprehended in the following general headings:

(a) Farm Power and Operating Equipment—power, implements, machines, and related equipment.
(b) Farm Structures—buildings and other structures and related equipment.
(c) Farm Sanitation—water supply; sewage disposal; lighting, heating, and ventilating of farm buildings, and related equipment.
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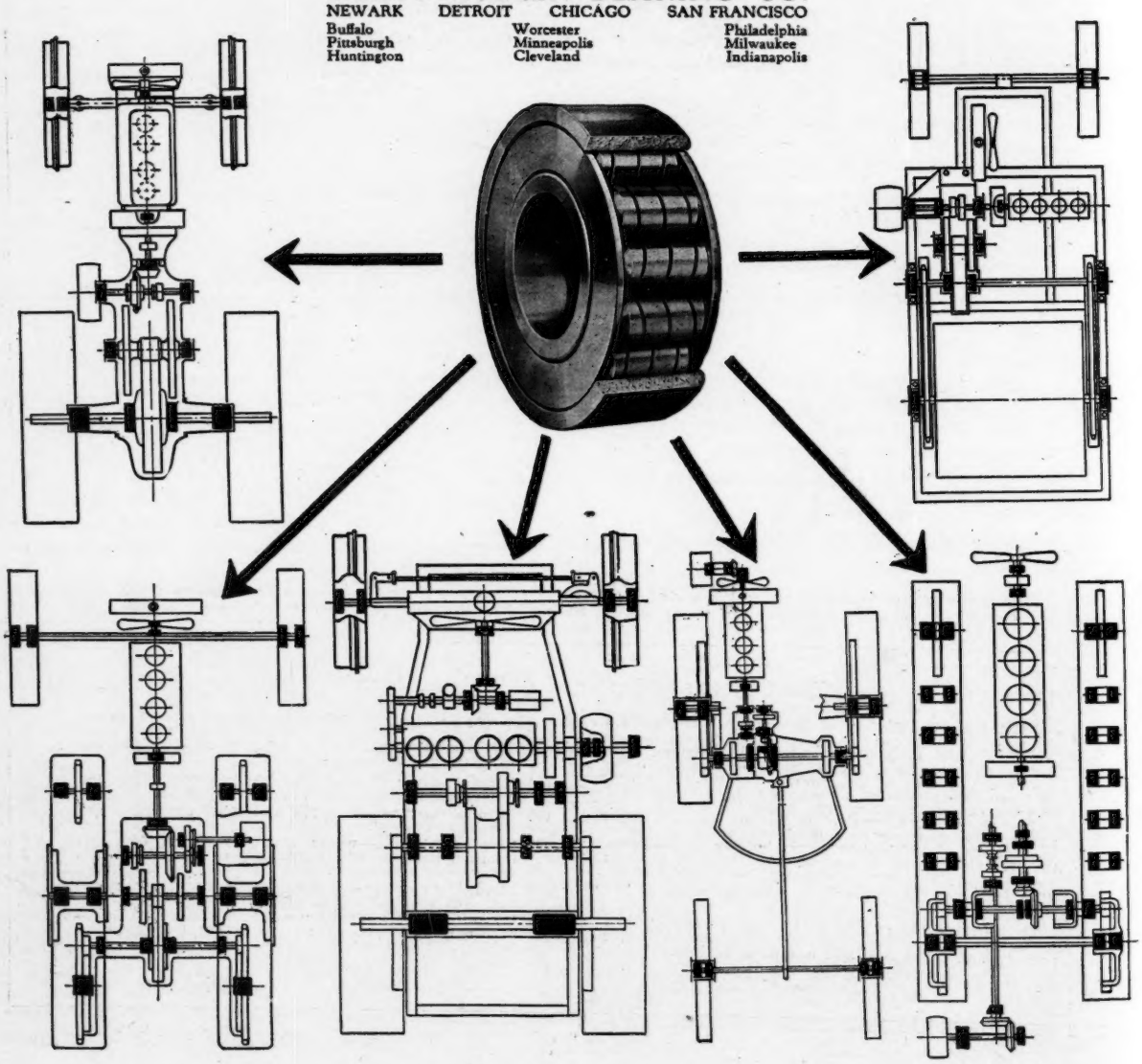

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Vol. 5 APRIL, 1924 No. 4

Is Tile Drainage a Real Source of Profit in Farming? *

By H. B. Roe

Member A. S. A. E. Associate Professor of Agricultural Engineering, University of Minnesota.

DRAINAGE engineers in the past have not been different from other kinds of engineers in that they have been largely satisfied to pursue the phantoms of methods and costs, apparently failing to note that those very costs constitute an investment in which the owner would be likely to find a far deeper interest in the actual or probable returns therefrom than in details of the investment itself.

The period of our entry into the late war marks a turning point in the mental trend of drainage engineers in common with other types of engineers toward the study of the real economic side of drainage and the promotion of drainage projects with more exactness on the basis of the economic return.

It is a common belief that the economic advantages of tile drainage are definite and very great. However, after three or four years of special study and search for definite facts based on actual experience and carefully checked up, I confess that, while I still believe in every one of the benefits of drainage that are commonly cited, I find the definite evidence available in support of these claims painfully meager and largely circumstantial. What definite evidence is available seems to be confined largely to the benefits of drainage accruing from (1) increase of tillable area within the present farm limits; (2) improvement in quantity and quality of crops, and (3) the reducing of the labor and consequent cost of farm operation by the squaring up of fields.

I shall stress largely the first and last of these three, drawing my evidence, which will be, to a considerable extent, ocular impression, from experiences and activities in drainage of the staff of the Minnesota Agricultural Experiment Station.

Some of these activities extend over a period of sixteen years from 1908 to date, especially on those projects having to do with benefits and costs. There are fifteen of these projects on which the cost data are practically complete, and in some cases there is other information of noticeable value.

Factors Entering Into Drainage Economics

The projects will be seen to be scattered pretty much all over those parts of the state where agriculture is tolerably well established. They therefore cover practically every variation found within the state, in type of soil, surface formation, rainfall, climatic factors, and type of farming, all of which factors affect the economics both of the general farm problem and of farm drainage, and tie these two problems very closely together in most details.

Rainfall has always been recognized as a leading factor in drainage considerations as have also other meteorological conditions. The recognition of soil types and conditions as a factor in economical drainage design has, however, come but tardily and only within the last few years. The drainage engineer now fully realizes that the permeability or retentivity of soils is the main factor in determining how rapidly soil water will reach subdrains, and therefore how deep and at what intervals they must be placed for greatest efficiency and economy.

Principal Elements of Gross Earnings on the Farm

In places in this discussion it is found necessary to draw some general conclusions and to estimate averages

* Paper presented at the Seventeenth Annual Meeting of the American Society of Agricultural Engineers, Chicago, November, 1923.

(Left) Marsh pocket on Minnesota state fruit breeding farm. (Right) Corn on the same spot after drainage.

partly on the basis of drainage benefits direct and partly on the basis of division of gross and net earnings on the farm, into their principal elements, thus correlating drainage and other farm management data. For this purpose, where necessary, the general average size of farm, average investment, division of earnings, and approximate percentages of the latter constituting the principal elements as determined and used by the farm management staff of the Minnesota station in general statements and arguments will be followed. These are approximately (1) Average size of farm, 160 acres; (2) average value per acre, $140; (3) average gross earnings per acre, $15; (4) average rate of interest on investment, 6 per cent; (5) division of gross earnings: (a) interest and materials (commonly designated as interest), about 55 per cent, or $8 per acre; (b) gross labor cost, about 40 per cent, or $6 per acre, of which about $2.50 is the average for the farmer's own labor; (c) overhead marketing costs, about 5 per cent, or $1 per acre.

Economic Effects of Increase in Tillable Area Within the Present Farm Limits

As the wet or waste land usually has to be gone around or over anyway in operations on the tillable portion, thus probably requiring as much labor as if the waste land were usable and cultivated for a crop, it is evident that if, after tile drainage, 100 per cent of the farm area can be cultivated and crops produced on it practically for what has been the total cost of doing the same on only 68 per cent of the farm area, the unit cost of production has been lowered an amount, expressed in percentage, equal to the difference between the cost per tillable acre before and after tile drainage divided by the cost per tillable acre before tile drainage, or (1/68—1/100 ÷1/68), 32 per cent very nearly. If the cost of tile drainage averages only $74.41 per acre against an average value per acre of the land tillable before drainage of $165.76, it further becomes evident that wet land can be reclaimed for approximately 45 per cent of the value of land on the same farm not needing drainage. Further, if 32 per cent of the average farm needs reclaiming by drainage, it is clear that the working capital in the shape of additional acres is thus increased 32/68, or approximately 47 per cent so far as its income-producing power is concerned. Finally it appears that, as this addition of 47 per cent to the working capital is made at an additional expense of only 45 per cent of the value of the originally tillable land, the actual cost of the 47 per cent increase in income-producing investment is but 45 per cent of 47 per cent, or 21 per cent of the value of the original investment in the originally tillable portion of the land. Hence, there is an average increase in crop income due alone to increase of tillable land area, of (47÷121) approximately 38 per cent.

Available data on cropping returns on individual farms in dollars or bushels per acre and on actual increase in market value of newly tiled lands are especially meager, but what there is may be of interest.

Item 2 of the accompanying table (Table I.) was tiled out in 1909. Only the east half of the tract was drained. It was told last year by the superintendent that the untiled land in that district was valued at from $60 to $75 per acre and the tiled land at least 25 per cent higher, or from $75 to $95 per acre, due alone to the greater assurance of a crop.

Item 10 of the table was tiled out in 1918, and the next year the old lake bed of about 60 acres alone produced 750 bushels of flax worth $4.00 per bushel, or a total of $3,000. Of this the total net returns to the farmer, including wages for his own labor and interest on farm investment, being about 70 per cent of the gross return, would be about $35 per acre, which would make a net total, on only 80 per cent of his land increase, of $2,100, which is 25.8 per cent return on the drainage investment for the 60 acres involved. Tihs amount spread over the 180 acres of the watershed on the farm tillable before drainage would amount to an increase in net farm income of $11.67 per acre, which for that year was a gain of 116.7 per cent over normal. However, it must be admitted that the results are not always so gratifying. Late

TABLE I

Comparison of Cost of Reclamation by Drainage with Value of Land for Farming Purposes, Based on Producing Power.

Item Number	Number of Owners	Designation of Owners	Town	County	Date of drainage Installation: Month	Year	Classification of Land: Heavily Rolling	Rolling	Gently Rolling	Mixed	Flat	Peat	Area in Acres: Watershed within boundary of farm drained	Reclaimed	Percent of Watershed on Farm Reclaimed	Estimated Value in Dollars per Acre: for total Watershed on farm	Resultant - for area tillable without drainage	Total cost of drainage in dollars	Cost of drainage in Dollars: Per Acre of Watershed on Farm	Per acre reclaimed	Advantage of Cost of drainage over New land purchase: Based on Entire Area of Watershed on Farm: Dollars per acre	per cent	Based on area tillable before drainage: Dollars per acre	per cent
1	1	a	Zumbra Heights	Carver	Aug-Nov.	1908			✓				72.89	10	13.72	105	121.71	615.00	8.44	61.50	43.50	41.43	60.21	49.47
2	1	b	Opposite Halstad Minn	Traill Co., N. Dak.	May-Jun.	1909					✓		160.00	80	50.00	65	130.00	4647.08	29.20	58.09	6.91	10.63	71.91	55.32
3	1	c	Belle Plaine	Scott Co.	Sept-Oct.	1909		✓					76.00	14	18.42	75	91.98	758.02	9.97	54.14	20.80	27.81	37.80	41.11
4	1	a	Grand Rapids	Itasca	July-Sept.	1910				✓			185.00	100	54.05	50	108.80	3710.94	20.06	37.11	12.89	25.78	71.71	65.89
5	1	d	Oakland	Freeborn	Oct-Nov.	1910					✓		120.00	95	79.17	40	192.00	1544.77	12.87	16.26	23.74	59.35	175.74	91.53
6	1	e	Osakis	Douglas	May-Jun.	1911		✓					120.00	8	0.67	125	193.93	1288.30	10.74	161.04	-36.04	-28.83	-27.11	-20.24
7	1	f	Faribault	Rice	July-Nov.	1911		✓					237.00	56	23.63	125	163.67	3529.27	14.89	63.02	61.98	49.54	100.65	61.56
					June-Aug.	1912																		
8	1	g	Fargo	Cass Co. N. Dak.	June-Aug.	1915					✓		95.00	32	33.68	100	150.79	4740.67	49.90	148.15	-48.15	-48.15	2.64	1.75
9	1	h	Moorhead	Clay	Sept-Nov.	1916					✓		300.00	76	25.33	125	167.41	7483.74	24.95	98.47	26.53	21.22	68.94	41.18
10	1	k	Glyndon	Clay	May-Nov.	1918					✓		255.00	75	29.41	100	141.67	10168.93	39.88	135.59	-35.59	-35.59	6.08	4.29
11	1	m	Coon Creek	Anoka	Aug-Oct.	1918																		
					Apr.-May	1919						✓	40.00	28	70.00	20	66.67	2932.00	73.30	104.71	-84.71	-123.58	-38.04	-57.06
					Nov-Dec	1921																		
					May-June	1922																		
12	6	m,co m,	New Market	Scott	July-Sept.	1919	✓						500.00	120	24.00	175	230.26	9065.27	18.13	75.54	99.46	56.83	154.72	67.19
13	1	a	Fens	St. Louis	May-June	1919						✓	20.00	15	75.00	50	200.00	1038.13	51.91	69.21	-19.21	-38.42	130.79	65.40
14	1	p	Foxarsville	Stearns	Jun-Sept.	1921		✓					138.84	35	25.21	125	167.13	3749.50	27.00	107.13	17.87	14.30	60.00	35.90
15	1	s	Meadowland	St. Louis	Oct-Nov.	1921					✓		7.00	2.50	35.71	50	77.78	277.92	39.70	111.17	-61.17	-122.34	-33.39	-42.93
15	18		Totals	12			1	4	1	1	6	2	2326.73	746.50				55543.59						
Weighted arithmetic average															32.08	112.58	165.76		23.87	74.41	38.17	33.90	91.35	55.11

in June of 1920, a very heavy flood from excessive rainfall (between 5 and 6 inches over three successive days) in the Glyndon district of the Red River Valley in which this farm lies, kept the old lake bed flooded for ten days or more and the potato crop planted that spring was a total loss.

In 1921, in spite of a similar flood in June of that year, the old lake bed yielded 10 bushels of wheat to the acre, worth $1.50 per bushel, making the probable net return about $10.65 per acre, which is 7.8 per cent on the drainage investment, the net increase over normal in his income being 35.5 per cent.

Returns for 1922 are not given except to say that the old lake bed showed no differences from the other fields and that the yields were fair for so dry a season. The average for the three years on which returns were given amounts to about 11¼ per cent on the drainage investment, from land increase alone, or 74 per cent increase in net income for the same cause.

Item 12 of the table includes parts of six farms tiled out co-operatively in 1919. Not all the owners on this project have as yet taken full advantage of the effect of the tiling to improve their fields, but one 60-acre tract very clearly illustrates both central arguments of this paper. On this tract the land increase was about 20 acres, and the testimony of the owner is that the crops on the reclaimed land continue to run with fair uniformity from 3 to 5 bushels to the acre, or about 15 per cent better than on the original cultivated areas not requiring drainage, which would indicate an advance in income of about 38 per cent, which result again justifies the general average previously given. The owner reports getting $200 worth of hay off the 20 acres of wet land in 1919 before it was drained, while in 1920 the same 20 acres yielded $800 worth of corn, making an increase of income, without added labor charge, of $600. That was an unusual year, but it gave 35 per cent return on the total drainage investment for the 60-acre tract of about $1,700, or a 100 per cent increase in net income on the 60 acres. The more or less uniform net improvement of 15 per cent above mentioned would indicate that ordinarily the average conditions previously used in this discussion should fit this case also fairly well. At $10 per acre total net return the return on the drainage investment on this tract should ordinarily be about (10 x 20 ÷ 1700) 11¾ per cent. This averaged with the 35 per cent for 1920, gives an average return of approximately 23 per cent, or 33 1/3 per cent increase on the net income for the 60 acres. Both of these figures may seem unreasonably high but the great satisfaction of the owners on this project, over the results of the tile draining, still continuing unabated after four years, seems to give good support to them.

Item 14 of the table was largely a dirty, miry, shallow peat bog before it was drained. It was tiled out in 1921 at a cost to the owner of $3,750. The following year (1922) the 30-acre swamp produced 412 bushels of flax, the gross return from which was $975. The actual cost of production that year, including breaking, disking, seeding, harvesting and threshing, was $369, which left a net return of $606, amounting to 16 per cent on the drainage investment, or an increase of (606÷10x104) 58¼ per cent in income, due to land increase alone. This year it was too dry everywhere in the district for good results so that the total return from the tract, which was cut up this season into six small, regular fields as nurse grounds for various seed grains obtained from the state experiment station, was poor. Twelve acres in hay failed to produce a crop; barley produced at the rate of 23 bushels to the acre; wheat, 10 bushels; oats, 39 bushels, and flax, 10 bushels, the total gross return being $432. Expense returns for this season have not yet been made but the rate of gross return is seen to be not greater than 50 per cent of the preceding year. Even that, however, would give about 8 per cent on the drainage investment, or about 29 per cent increase in income.

There is too little exact evidence on hand to justify an attempt to draw final and definite conclusions as to actual percentage of return on drainage investment due to land increase alone or as to increase in farm income from the same cause. If, however, what has been presented is at all indicative of the tendency in these directions, that tendency is seen in Table II. In this table, if in the case of Item 12 and 35 per cent averaged in with the 11¾ per cent is considered excessive, it still leaves the two final averages in this table about 58 per cent and 11½ per cent.

Economic Effects of Drainage in Squaring Up of Fields

In relation to the influence of drainage in rectifying of field lines and the effect of this benefit on income, I will take eight cases selected from our tiling projects as being the most marked cases of this kind:

I. An 80-acre farm in Carver County (Item 3 of Table I), (see accompanying map)—twelve irregular fields and three unusuable swamps changed to nine regular fields.

II. A 160-acre farm in Douglass County (Item 6 of Table I.), (see accompanying map)—seventeen irregular fields changed to thirteen regular fields, exclusive of farmstead tract.

III. Eighty-seven acres of a 237-acre farm in Rice County (part of Item 7 of Table I)—seven irregular fields, two being swamp, changed to six regular fields.

IV. A 236-acre farm in Clay County (part of Item 9 of Table I.)—five irregular fields changed to five regular ones.

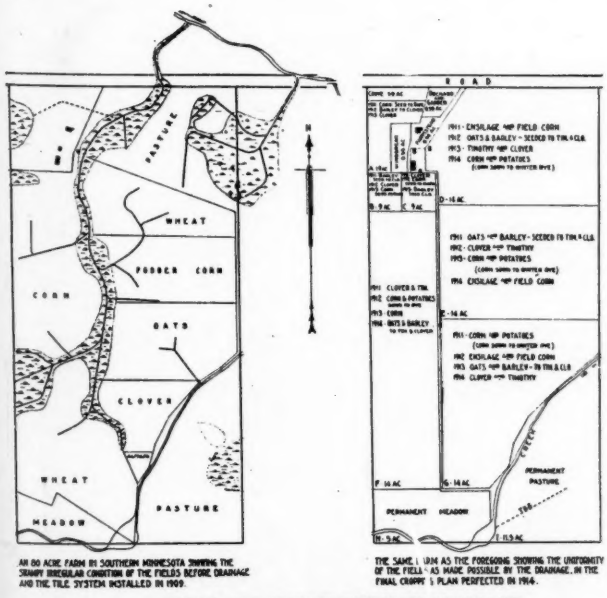
V. One hundred and sixty acres out of 255 acres on a Clay County farm (part of Item 10 of Table I.)—six irregular fields and a marshy pond changed to five regular fields.

VI. A 20-acre tract out of a Scott County farm (a small part of Item 12 of Table I.)—three irregular fields and a swamp changed to three regular fields.

VII. A 60-acre tract (the one before mentioned under Item 12 of Table I.), a part of a Scott County farm—six irregular fields changed to three regular ones, all of which could readily be farmed as one as the owner freely testifies.

VIII. A 35-acre tract on a Stearns County farm (Item 14 of Table I.) so reclaimed as to be available in any shape desired.

These cases seem to indicate that the general tendency is to reduce the number of fields about one-third; but that is not the important point. In squaring up the fields, the great advantage is in the saving of travel and of profitless moving of implements and machinery in farming operations. I am not aware that any exact investigations have been made of money savings in this way but the testimony of farmers



AN 80 ACRE FARM IN SOUTHERN MINNESOTA SHOWING THE SWAMPY IRREGULAR CONDITION OF THE FIELDS BEFORE DRAINAGE AND THE TILE SYSTEM INSTALLED IN 1909.

THE SAME LAND AS THE FOREGOING SHOWING THE UNIFORMITY OF THE FIELDS AS MADE POSSIBLE BY THE DRAINAGE, IN THE FINAL CROPPING PLAN PERFECTED IN 1916.

A TYPICAL TILE DRAINAGE SYSTEM FOR ROLLING LAND.

NOTE: THE INCOME FROM THIS FARM INCREASED PRIMARILY AS A RESULT OF DRAINAGE. FROM $990.00 IN 1908 TO $2490.00 IN 1912

This map shows the arrangement of fields on an 80-acre farm in Carver County, Minnesota, before and after drainage.

who have drained their wet land is universally in the same direction.

The owner of Item I. was enabled, almost wholly as a result of drainage—according to Mr. Thomas Cooper, formerly assistant in farm management at Minnesota, now dean of agriculture at the University of Kentucky—to practically treble the income from his farm inside of three years, about 20 per cent of this being due to increased tillable area and fully one-third of it to reduction, due wholly to drainage, of labor in necessary travel and tillage operations.

The same may be said of the farm in Item II.

The tract in Item III. was scarcely any of it tillable at all before drainage, so it is certainly conservative to say that cultivation of it after drainage has been made at least one-half easier than before.

On Item IV. there is no exact evidence available.

On Item V. the owner testifies that cultivation is about one-quarter easier.

On Item VI. there is no exact evidence.

On Item VII. the owner has testified one-third to one-half easier.

On Item VIII. the owner testifies that the operation of his whole farm is fully one-third easier.

Table III. shows these carried out on the basis of acres affected to a weighted arithmetic average.

The table indicates that the tendency seems to be for squaring up of the fields, made possible by drainage, to cut cost of field operations about one-third. This at first looks well nigh unbelievable as this decrease in cost would at once add to the net income. It is seemingly born out, however, in cases where the income from drained lands pays for the drainage in from one to five years, and in cases of farms which are as badly in need of drainage improvement as was Item I. of Table III. Further, this 36 per cent saving is on the total labor cost of $6 per acre and amounts to $2.16, which would be at once added to the total net profit of $10, the per cent increase being (2.16÷10) 21.6 per cent.

This increased net profit reckoned as interest on the drainage investment of $23.87 per acre of watershed on the farm would amount to (2.16÷23.87) or 9 per cent plus on the investment.

Influence of Drainage on Quantity and Quality of Crop Through Earlier Drawing of Frost and Drying of Fields in Spring

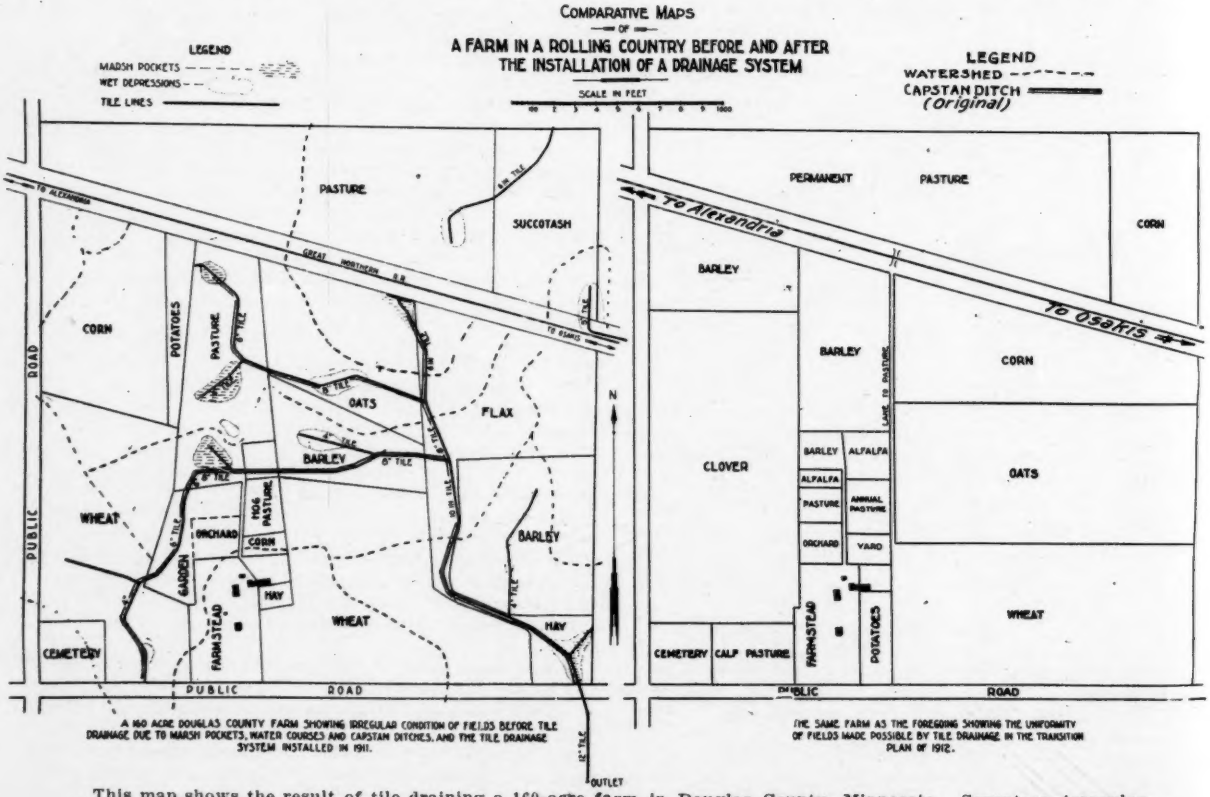
According to some unpublished data by Prof. A. C. Arny of the division of farm management at the University of Minnesota and used here with his permission, the following results taken from a three years' observation, show losses from seeding being thirty days later than normal. (See Table IV.) Other lengths of time less than thirty days show results consistent with the above. Therefore, it is apparent that earlier thawing out and drying of the ground in the spring due to drainage, where this amounts to from one to two weeks, tends to prevent loss of final crop much as shown in Table V.

Assuming about equal value of these three crops, the average saving from loss would be about 27 per cent. On the same basis of reduction as other items in this discussion this percentage of saving would amount to $2.70 per acre in net income, which in turn would become (2.70÷23.87) 11.3 per cent virtual income on drainage investment.

Prof. Arny further states that one of the most important benefits of tile drainage which is a matter of common observation, particularly in southwestern Minnesota, is that the better physical condition of the soil resulting, from drainage, in better root growth and more vigorous plants ultimates in a full maturing of crops—particularly corn—from one to two weeks earlier than on undrained land, with a consequent noticeable rise in quality of the crop; but this experience has never been worked out in economic terms of dollars and cents or of bushels per acre, although occular evidence is quite clear that crops on tile drained land usually present this vigorous appearance.

Summary and Conclusions on Evidence

What has been presented is too scattered and general



This map shows the result of tile draining a 160-acre farm in Douglas County, Minnesota. Seventeen irregular-shaped fields were converted into thirteen regular-shaped fields.

to warrant any hard and fast conclusions. The following summary of figures presented herein is offered for what it is worth. (See Table VI.)

The subject of more vigorous plant growth due to drainage was mentioned not only for the definite interest it must of itself arouse, but more particularly to introduce the subject of great need for more extended research in drainage and to open the way to pointing out some of the fields in the economics of drainage that are ripe for research.

We drainage men are wont to talk frequently and with considerable assurance about many other supposed benefits of drainage than those I have discussed, commonly listing them about as follows:

I. Improvement in quality and quantity of crops due to:
   1. Increase in length of growing season by better aeration of the soil and warding off of late spring and early fall frosts.
   2. Checking, heaving, and winter-killing.
   3. Increasing capacity of the root bed with resulting earlier maturing of crops.

II. Insurance against drouth:
   1. By providing larger storage space for reserve moisture.
   2. Inducing better distribution of moisture, checking evaporation and consequent baking and cracking of the soil.
   3. Improving soil structure with better tilth resultant, providing deeper feeding ground.

III. Improvement in chemical condition of the soil by removal of excess acid and alkali, and by aid to decay and nitrification.

IV. Preservation of fertilizer and prevention of floods.

V. General moral influence. Improvement in appearance and market value of the farm, thus stimulating the pride and interest of the farmer in his work.

Have we the facts and their economic bearings to justify our arguments? Except perhaps in the matter of improvement in chemical condition of the soil, I have to date been unable to find usable economic data on the points just listed. We have in Minnesota one definite bit of data on early drawing of frost, that is given in Minnesota Special Bulletin 67 with reference to the Peat Experiment Station at Fens, forty miles north of Duluth. Even for this the data are not in exact economic terms although, through drainage aided by proper fertilization, rye yielding 34 bushels to the acre and onions running 1,000 bushels to the acre as well as other interesting yields in truck crops were secured that year that even seem to justify the $200 and upwards per acre that it seems to cost to put such land under proper cultivation.

A notable fact was discovered at the Wisconsin station a short time ago. Mr. Jones and Mr. Elliott investigating depth of corn roots in peat found that they will, under proper drainage conditions, penetrate to a depth of at least 42 inches, but it was also found that in no case would these roots penetrate to a depth greater than 18 inches above the water table in the peat soil. This quite definitely fixed the efficient depth of tile in peat soil when corn is the crop; but it did much more. It raised the whole question of how deep the roots of our various crops will penetrate in any kind of soil under the proper conditions of drainage. Is it not quite possible, yes even probable, that there may be in any soil and with every crop this definite zone of no root growth just above the ground water table. Much is known of root penetration with differing crops and in different soils, but has the subject ever been studied and results given to the public with reference to drainage needs and proper drainage design?

Just how great are all these various effects of drainage and just what is their economic bearing? I have heard more than one of them questioned by thinking men during the past two years and there has been no available answer except what I have called the common sense of the situation; but that does not satisfy.

We are carrying out in Minnesota four major lines of drainage investigation, all intimately related to the economic side of the drainage problem. They are:

Table II.—Percentage Increase in Net Farm Income Due to Drainage and Rate of Income on Total Drainage Investment.

Item number in Table I.	Total acres tillable before drainage	Avg. pct. increase in farm income	Product	Total acres reclaimed	Avg. per cent return on drainage investment	Product
10	180	74	13,320	60	11¼	6,750
12	60	66-2/3	4,000	20	23	4,600
14	104	58¼	6,058	30	12	3,600
Totals	344		23,378	110		14,950
Weighted average		68			13.6	

Table III.—Average Advantage to Farm Operation from the Squaring Up of Fields Resulting from Drainage

Item No.	Corresponding Item in Table I.	Total acres in tract	Advantage	Product
I.	3	80	1/3	26 2/3
II.	6	120	1/3	40
III.	7	87	1/2	43 1/2
V.	10	160	1/3	53 1/3
VII.	12	60	2/5	24
VIII.	14	139	1/3	46 1/3
Totals		646		233 5/6

Weighted averages, 36% plus.

Table IV.—Loss of Crop with Small Grains Due to Late Planting (after Arny).

Kind of grain	Days late	Limits of percentage of loss
Barley	30	33.9 to 47.8
Oats	30	44.5 to 56.3
Wheat		67.7
Wheat	20	45.0 to 56.8

Table V.—Approximate Loss of Crop with Small Grains Due to Planting One to Two Weeks Late.

Kind of grain	Limits of percentage of loss	Approximate avg. Loss for all grains, 27%
Barley	10.2 to 20.5	
Oats	12.6 to 25.2	
Wheat	17.8 to 35.7	

Table VI.—Summary of Percentages of Increase in Net Farm Income Due to Drainage, and of Rates of Income on Total Drainage Investment

Influencing factor	Average pct. increase in farm income	Average pct. return on drainage investment
Increase in tillable area.....	68	13.6
Squaring up of fields.....	21.6	9.0
Totals always working.....	89.6	22.6
Earlier seeding time.....	27.0	11.3
Possible totals according to general character of spring.	116.6	33.9

1. Study of economical and efficient methods of drainage installation and a correlation between waste land reclamation within the farm limits and the normal income from and value of tillable land.

2. A study of soil permeability for the most efficient depth and spacing of drainage lines for the prompt removal of excess moisture in the soil.

3. A study of agricultural development of peat lands through drainage and control of the ground water level.

4. A study of the causes of failure of drain tile and of the materials and methods of manufacture of drain tile to obviate such liability to failure.

We hope before very long to be able to put before the interested public at least a preliminary report of some interesting and valuable findings on these questions, but our forces and our funds are limited and will be still more so in the near future. The cry against more drainage by a large and wealthy group of people, who do not know the farmer's problem and who are not particularly interested to know it, is becoming more and more insistent and aggressive, and it is becoming increasingly difficult to put across drainage projects in Minnesota. We need to get the economic facts more firmly in hand.

I would like to see started in our north Mississippi basin at least four more major projects covering essentially the practically untouched phases I have herein outlined; for example, one on economic influences of drainage as a preventive of drouth, one on economic effects of drainage on lengthening of the growing season and on the earlier maturing of crops, one on root penetration in relation to drainage, and one on economic value of drainage in strengthening the morale of the farming enterprise. I would like to see this work pushed with a vigor that will put the essential economic facts into our hands at least in a preliminary way within from three to five years.

Building and Equipment Factors in the Cost of Dairy Products*

By Deane G. Carter

Assoc. Mem. A. S. A. E. Professor of Agricultural Engineering, University of Arkansas

WE have always considered that the design of any farm building to a large extent is a special problem depending upon the type of farming, location, number of head of stock, and similar factors, and further, the amount of money expended for farm barns and equipment is a variable quantity depending upon the value of the farm, the market price of the finished products, and the ability of the owner to pay for such improvements.

Economy in farm buildings and equipment lies in "building for the purpose intended." Some specifications call for an outlay of more than $60 per cow for barn equipment alone. On the other hand, there are installations where $400 has provided a practical though not a complete installation for fifty cows. The purpose in this case was to produce market milk and butterfat on the most economical basis. Another case in point is a certain dairy which some years ago supplied milk for the city of Fargo, North Dakota. This barn did not have a single piece of modern equipment, had wooden floors instead of concrete, and was poorly arranged throughout. Yet this particular dairy consistantly produced milk with a lower bacterial count than any of its competitors, because an enormous amount of labor was expended to clean and wash the barn, brush the animals carefully, and arrange the work so that there would be no floating dust in the barn at milking time. However, this layout was not economical because more than enough labor was wasted to pay for an investment in modern equipment.

Between the extremes of high and low equipment costs, there is a middle cost that will afford labor-saving, sanitary equipment at a price that will enable the operator to make a profit on his installation.

The division of farm management of the college of agriculture of the University of California completed records on March 1, 1923, showing all factors entering into the cost of producing market milk and butterfat in two hundred forty-six California dairies. The committee is indebted to the farm management division at California for this report which is summarized in the following paragraphs:

Although the records are for various sections of California and, therefore, not exactly comparable with conditions in the Middle West, it is an exhaustive investigation and forms a basis from which we can determine the percentage of cost of production chargeable to building, yards, and equipment.

Some of the Cost Factors Entering Into the Production of Market Milk and Butterfat

These figures are the result of findings obtained from 14,250 cows of two hundred forty-six daires situated in 11 dairy sections of California. The records cover an entire year's business on each dairy, and for the most part the records were for the year ending March 1, 1923. Dairies producing certified milk were not considered; thus they confined the result to dairies strictly concerned in the production of whole milk or butterfat. Sectional variations between dairies is not of sufficient importance to warrant a discussion in detail. For the most part the results here given are averages of all of the 11 sections studied, although there were some wide variations in costs, capacity, etc. The average cost of the two hundred forty-six dairy barns considered per cow capacity was about $34. The age of the barns considered ranged from one year to more than 50 years. Many were more than 30 years old, and many are of a lighter construction than barns of the Middle West. In addition to the per cow cost of the milking barns, the building costs included milk houses, also feed sheds or silos if used. The average cost of milk houses per square foot was $1.45. The cost of feed sheds or storage buildings ranged from 2 to 3 cents per cubic foot, with an approximate average of 2.4 cents per cubic foot. The cost of the silos was based on the capacity, and ranged from $2.17 per ton in the San Diego district to $7.39 in the Sacramento district. The general average of results was $5 per ton capacity. The cost of the silos, milk houses, and feed sheds was included along with the milking barns in the percentage figures given later. The total investment in buildings per cow for all the districts was $54.50. The figures are in all cases the original cost of the buildings, and not the amount that would be required to replace them at the present time.

In order to figure the depreciation, estimates were secured from all of the cooperating dairymen considering the probable life of the buildings and equipment. Although these figures are guesses, they are the best available data and represent the composite view of a large number of practical men. The following shows the estimated rate of depreciation in all sections studied for milking barns and other dairy buildings. The estimated depreciation on milking barns was three per cent per year, indicating an average life of thirty-three years. Milk houses were estimated approximately the same. Feed sheds were estimated to have a life of about twenty-five years and silos twenty years.

Investment in Equipment per Cow and the Rate of Depreciation From Survey Figures

The dairy equipment which was included as a part of the building cost, such as stalls, stanchions, litter carriers, etc., was not valued separately in the survey, but were included in the cost of the milking barns. (We hope to present some figures later showing the relation of building equipment to the cost of the barn.) However, the other items of equipment such as cream separators, milk pails, cans, milking machines, testers, shovels, etc., were estimated separately in the two following tables. As shown, the investment in these items are equipment per cow and also the estimated life and rate of depreciation.

It should be noted in particular that the survey shows the investment in equipment per cow ranges from $5.41 up to more than $15 per cow, and the rate of depreciation ranges from about 12 per cent on cream separators, milking machines, and wagons, up to more than 30 per cent of a number of items. This indicates rather a larger investment than is usually estimated, and a rather high rate of depreciation. It is probable, however, that the necessary items of equipment represent a smaller investment by several dollars than is represented by the cost of permanent equipment, such as stalls and carriers.

District	Investment in equipment per cow
Humboldt-Del Norte	$8.18
Marin-Sonoma	12.95
Alameda-Contra Costa-Santa Clara	11.42
Sacramento-Yolo	5.41
San Joaquin-Stanislaus	11.82
Fresno	11.32
Kern	9.52
Los Angeles-Orange	5.65
San Deigo	15.69
San Luis Obispo	11.33
Monterey-San Benito-Santa Cruz	9.00

*1923 report of the A. S. A. E. Committee on Farm Building Equipment.

Dairymen's Estimates of Depreciation of Selected Items of Dairy Equipment—Average for All Districts Studied

Item	years Estimated life (Range in years reported	years Estimated life (Average of opinion)	Percentage rate of depreciation based on average life
Can racks	2-16	8.7	12
Coolers	1-30	7.9	13
Lanterns	1/2-20	3.2	31
Milk cans	1-15	5.0	20
Milk buckets	2/3-8	3.0	33
Milking machines	4-20	8.7	12
Milk pails	1/2-20	3.5	29
Milk testers	1-40	5.0	20
Milk vats	2-40	8.1	12
Pitchforks	1/2-15	2.8	36
Separators	3-30	9.8	10
Shovels	1/3-25	3.2	31
Sterilizers	2-20	4.5	22
Veterinary outfits	5-20	7.5	13
Wagons and carts	2-25	8.3	12
Wash tubs	1-20	5.7	18
Wheelbarrows	2-20	5.5	18

For the purpose of reference and comparison, the table below gives the average annual cost of upkeep on buildings and yards figured on the basis of each hundred dollars invested.

District	Upkeep Costs of Buildings (Per $100 of investment)	Corrals (Per $100 of investment)
Humboldt-Del Norte (Arcata)	$0.64	$4.82
(Orick-Requa)	1.38	0.2
Marin-Sonoma	1.92	2.23
Alameda, Contra Costa, Santa Clara	.88	.16
Sacramento-Yolo	3.55	2.34
San Joaquin-Stanislaus	.89	
Fresno	1.74	2.36
Kern	4.77	4.88
Los Angeles-Orange	1.52	3.62
San Deigo	2.00	.27
Monterey, San Benito, San Cruz	1.75	2.79
San Luis Obispo	.92	.77

An idea of the relative importance of the different items going to make up the cost of production can be gained from the following percentage table of each item entering into the total cost. Lack of space prevents giving the entire data, but the following summary gives the important figures in two of the eleven districts. It shows that 11.2 per cent and 7.3 per cent, respectively, of the total cost of production was chargeable to buildings and equipment.

Items	Sacramento-Yolo District Per cent	Fresno District Per cent
Labor	28.6	30.0
Feed	47.2	45.9
Hauling	3.3	4.1
Supplies	2.1	2.0
Interest on operating capital	0.3	0.2
Herd charge	7.3	10.5
Building charges	7.1	3.4
Yardage	2.5	0.9
Equipment	1.6	3.0
Total	100	100

The following table shows the building charge distribution (exclusive of corrals and dairy equipment):

Items	Sacramento-Yolo District Per cent	Fresno District Per cent
Interest	2.6	1.4
Depreciation	2.1	1.3
Upkeep	1.6	.4
Taxes	.4	.2
Insurance	.4	.1
Total buildings	7.1	3.4

The above table of itemized building charges shows how the percentage is divided among interest, depreciation, etc.

Bulletin No. 1144 of the U. S. Department of Agriculture gives figures on the cost of milk production on forty-eight Wisconsin farms, the conclusion is reached that the average investment on dairy equipment per cow is $3.30, and the average cost per cow for shelter and feed storage is $12.50.

Distributing these costs for buildings and equipment on the basis of average production, it was found that the building and equipment costs amount to 20½ cents for each hundred pounds of milk produced.

The cost of producing one hundred pounds of milk in the year 1920 totaled $3.30, or approximately 6 per cent of the cost of production was directly chargeable to building and equipment.

This may be compared with the reported California cost of 11.2 per cent in the Sacramento-Yolo district, and 7.3 per cent in the Fresno District.

E. J. Stirniman, a member of the Committee on Farm Building Equipment, made a servey of some fifteen or twenty dairies in California during the past year in order to determine the cost of barn equipment per cow as a separate item. These figures are being tabulated at present and are not available. They should show the percentage of production cost that can be charged directly to the dairy stable equipment such as stalls, stanchions, litter carriers, feed carriers, and watering equipment.

COMMITTEE OF FARM BUILDING EQUIPMENT

D. G. Carter, Chairman
J. B. Clay
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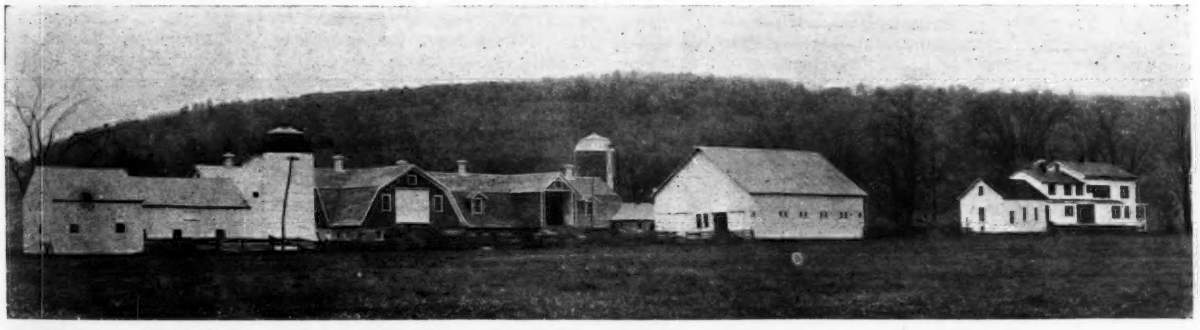


The planning of such a plant as the one shown here, including design and the arrangement of the various units, calls for the best agricultural engineering skill

Measurement of Seepage Losses in Canals*

By O. V. P. Stout

Mem. A. S. A. E. Department of Rural Institutions, University of California

THE water carried in the channels of an irrigation system is subject to losses due to the water seeping through the bottom and sides. This is true without exception, but the extent to which such seepage takes place varies through a wide range, depending upon a number of causes. Some of these causes are the nature of the soil traversed, the treatment which has been accorded the channels, the length of time that they have been in service, the velocities and depths with which the water flows through them, and the amount and character of the suspended matter carried by the water. The evil effects of seepage embrace, in addition to the loss of water which it has cost money to transport and in many instances to develop and pump, the water-logging of lands, rise of alkali and the creation of unsanitary conditions. They outnumber and outweigh the beneficial effects, which are limited to special conditions under which the seeped water spreads through the subsoil at a depth suitable to the growth of orchard, vineyard and other crops, or which permit the seeped water to return to natural channels and augment or equalize the supply from such channels, all without being offset by the rise of alkali. Consequently the prevention of seepage, so far as it is economically possible, is usually a justifiable undertaking.

Seepage conditions, including the losses from main canals and lateral systems, affect the value of the security offered for the financing of irrigation works and of the operations of associations and individuals under such works. They are also a modifying factor in the administration of irrigation enterprises, influencing materially the distribution of water to lands, and calling upon the management to be on its guard against permitting damage to land and crops.

An element to be considered in arriving at a conclusion as to what may be economically justifiable in a project to prevent or reduce seepage is what the amount or rate of seepage is, what it may become at a later period, and what the residual seepage may amount to after measures in alleviation have been introduced. To furnish information on these points is one purpose of seepage measurements. Other purposes which may be noted are the securing of data to assist in the decision of suits at law relative to damage by seepage, in the adjudication of cases wherein one party seeks the right to use water which it is claimed is wasted by others who permit undue seepage to occur, and in the determination of allowances to be made in the distribution of water to irrigators.

One of the First Essentials Is Suitable Instruments for Measuring Surface Flow

Most of the principal conditions essential to the determination of seepage losses in irrigation channels are such as to occur readily to anyone who gives consideration to the subject. On the other hand, the rarity of the combination of these conditions, the difficulty of securing them, and the measure of the effect of even moderate departures from these conditions are not always appreciated.

One of the first and most obvious essentials is suitable instruments or devices for measuring the visible or surface flow into and out of the channel under investigation. Except for certain very shallow, narrow or sluggish streams, or those having very rough beds or containing considerable vegetable growth, the current meter has come to be recognized as the readiest and most generally available instrument. Under duly favorable conditions it compares well with the weir in respect of accuracy. Relatively few outside the ranks of research workers, however, have gained a full appreciation of the extent to which the reliability and accuracy of results obtained by means of either one of these devices are impaired by departure from the most favorable conditions for their use.

In the light of the above it appears that any investigation, extended as to time and territory, and covering a considerable range in size of channels, with funds and personnel somewhat limited, must depend chiefly upon the results of current meter measurements for the determination of losses from channels in service. Such measurements are supplemented or replaced, as a matter of course, when occasion offers or requires, by measurements effected by means of other devices. If suitable weirs are found already installed, use should be made of them. Small rectangular, trapezoidal and triangular weir notches of metal may be included in the portable equipment of the investigation. They are appropriate, where the necessary "measuring head" is available, for the measurement of the very small quantities which may be involved, such as persistent leaks from the headgates of laterals, small diversions, and small streams of waste water reentering the channel. Volumetric measurement of leaks is frequently found to be practicable, the conditions along this line offering some variety. Sometimes the leak is or may be a spouting stream which may be caught in a container of known capacity, and the time to fill observed. Again, it may be a trickle into a chamber, the outlet of which can be closed, thus permitting the rate of rise of the water surface to afford a means of computing the trickle. In this case note should be made if the rising water surface in the chamber diminishes the head under which the leak is taking place. In one instance the leak was outward from the chamber, and the measurement was effected by closing tightly the chamber inlet and determining the rate of fall of the water surface. In the matter of lateral inflow or outflow it should always be remembered, however, that the stopping of the flow, if practicable, is a better expedient than measurement by whatever method.

Some of the Details of Metering as Practiced in in Recent Seepage Investigations

Some of the details of metering, as it has been practiced in the recent seepage investigations under cooperative agreement between the Division of Agricultural Engineering, Bureau of Public Works, United States Department of Agriculture, and the Division of Engineering and Irrigation, Department of Public Works, State of California, will be given.

The method which is usually preferred and used is based on the determination of the mean velocity of the water across vertical lines located at short uniform intervals of distance across the channel. This interval of distance has rarely been more than two feet, although there is ground for the belief that in case of large canals the interval might have been made greater, resulting in a saving of time without impairing the accuracy of the work. To determine the mean velocity in a vertical, the usual procedure has been to measure the velocity at two-tenths of the depth and at eight-tenths, taking the mean of the two results as the mean in the vertical. Extended careful tests, including those made by the U. S. Department of Agriculture at Fort Collins, have established that under the conditions as commonly encountered this is one of the most reliable methods of obtaining the mean velocities in the verticals across stream. It is usually better than to attempt to secure greater refinement by resort to methods which occupy so much longer time that change of stage in the canal, or the shifting of velocities across the section, is liable to vitiate whatever of increased accuracy might otherwise accrue from more refined methods. The multiple-point method, in which velocities are measured at a

*Paper presented at the Pacific Coast meeting of the American Society of Agricultural Engineers, San Francisco, October, 1923.

number of points uniformly distributed throughout the vertical, will undoubtedly give more certainly the mean velocity in that vertical at that time. The time which may elapse, however, in the metering of a large canal, between the measurement in one vertical and that in another at some distance across stream from the first may be sufficient to cover the material shifting of velocities in the cross-section. Moreover, expedition in metering is important when the stage of water in the canal varies, as it nearly always does.

The 0.2 and 0.8 method is also the subject of some distrust under certain circumstances. It is believed, for instance, that a growth of vegetation on the bottom of the channel, by reducing bottom and near-bottom velocities nearly or quite to zero, deranges the vertical velocity curve, so that the relations upon which the accuracy of the 0.2 and 0.8 method depends no longer holds. Large stones or other irregularities of size in the beds of channels other than deep ones present much the same problem as the presence of plants. Where such conditions have been unavoidably encountered, and also in shallow depths—say, those less than one foot—vertical integration has been employed. This consists in moving the meter up and down at a constant slow rate in the vertical during the observation. It is generally considered as somewhat inferior to the 0.2 and 0.8 method in sections other than as those described above.

Measurement of Depths in Connection With the Determination of the Rate of Discharge

A common practice in metering is to count the revolutions for 50 seconds and compute therefrom the number of revolutions per second. In the present investigation the time, to the nearest fifth or tenth of a second, has been noted for an integral number of revolutions. Usually the run has been for at least 40 seconds, the idea being that that length of time is as little as can be depended upon to cover the cycle of pulsations which is always discernible in any considerable current, and also as little as will assure that the accidental error in noting the time will not be of material amount relative to the length of the observation.

The measurement of depths in connection with the determination of the rate of discharge of an open channel is a matter of equal importance with a knowledge of the velocity of flow, and the accomplishment of this in precise degree is quite generally as difficult as the measurement of velocities. In any other than placid currents the rise of the impinging water on a measuring rod is considerable, and the allowance for it uncertain and lacking in precision. On uneven bottom, or that covered with cobble stones or large gravels, a difference of an inch in the point at which the measuring rod is set down may make a difference of an inch or more in the resulting measured depth. It is further obvious that soft mud bottoms and those of shifting sand present difficulties. The depths have in some instances been determined by using an engineers' level to determine the relative elevations of the water surface and the bed of the channel. In a placid current flowing over a hard smooth bed this method is capable of a good degree of precision, but it is a well-known fact that in swiftly flowing water the surface across stream is not of uniform elevation, as this method assumes it to be.

Throughout the progress of the investigation there has been frequent recurrence to a consideration of the problem of devising some more precise method than that afforded by the current meter. Thus far it is not a helpful undertaking. For lined channels of regular form it seemed that a diaphragm cut to a precise fit in the channel might develop some merit. One was made and tried out in a concrete lined lateral. Although it gave good results, comparable to those of the current meter, it was found that the channel in which it was used was not perfectly regular, and while the irregularity was not enough to interfere with the operation of the diaphragm, the necessary computation of the volume of water contained in the length of channel passed over required a number of careful cross-sections and computations which consumed an undue amount of time. I am not prepared to say that such a device is wholly without use or place, but it was not deemed worthy of further trial in the present connection.

In the measurement of discharges for the purpose of ascertaining the rate of seepage loss, small accidental errors or inaccuracies, which may occur either in the direction of increasing the discharge or diminishing it, are a matter of greater concern than are equally small systematic errors, which occur always in the same direction. This can be illustrated by taking the case of a mile of canal which loses in the mile one per cent of the water which enters it. Suppose for a moment that we are able to avoid accidental errors, but that we have a systematic error of one per cent, the measured discharges at the inlet and outlet ends of the mile being each one per cent greater than the corresponding actual discharge. Then the resulting figures for seepage will be only one per cent greater than they should be. Now assume the systematic error to be eliminated, and that we are subject to and actually have an accidental error of one per cent, and that this accidental error is positive at the inlet end of the mile and negative at the outlet end. If Q is the actual discharge at the inlet end, then the measured discharge there will be 1.01 Q. The actual discharge at the outlet end of the mile will be 0.99 Q, and the measured discharge at this point will be one per cent less than this, 0.99x0.99 Q, or approximately 0.98 Q. According to the measured discharges the loss in the mile will therefore be 1.01 Q — 0.98 Q, or 0.03 Q, whereas its actual value is only 0.01 Q. Thus we have obtained a seepage rate three times as great as we should. Similarly it may be shown that if we had assumed the accidental error to be negative at the inlet end and positive at the outlet of the mile, our figures would show no loss at all, but a gain of one per cent in the discharge, instead of the actual loss of one per cent. This is a real difficulty which confronts any project to determine seepage losses which are small relatively to the discharge of the channel. It has been expressed as follows: "In measurements of discharge to determine small seepage losses, the losses are likely to be overshadowed by the unavoidable inaccuracies of measurement." In order to minimize this difficulty the effort is made to obtain as long stretches of canal as may be had under suitable conditions between gaging sections. A further expedient to the same end is the making of repeated sets of gagings at the two sections, thus tending to eliminate the purely accidental errors of observation. A statement which has been formulated with these matters in mind, and which reflects the idea of the relative importance of small accidental and systematic errors as above set forth is as follows: "It is more important that the measurements should be made to produce consistent results than that they should be precise to this limit."

For Gagings Select Inlet and outlet Points Where Water Cross-Sections of Channel Are Similar

Consistency in the results of gagings may be materially furthered by selecting inlet and outlet points at which the water cross-sections of the channel are similar. Experience indicates that this is an important consideration. For example, in one case of a large main canal the upper or inlet section and the lower or outlet section were in similar stretches of concrete-lined channel. The results obtained in a considerable series of gagings were quite consistent. Gagings were made also at an intermediate earth section, where the water was deeper and the velocity slower. The results at this section were not nearly so consistent with the results at either of the concrete-lined sections as the results at those two sections were with each other.

Pools have been found or created in irrigation channels in some places, and the rate of seepage therefrom has been determined by keeping a record of the drop of the water surface for a number of days. Under the best conditions this procedure gives accurate figures of the rate at which the seepage actually occurs. This may or may not be the same as from flowing water in the same channel, according to circumstances not yet clearly appreciated or defined. As representing the seepage rates under a falling water surface, they may or may not agree for any given height with those which obtain when the water surface is

(Continued on page 90)

The Utilization of Salvaged War Explosives in Cut Over Land Reclamation *

By John Swenehart

Mem. A. S. A. E. Associate Professor of Agricultural Engineering, University of Wisconsin

THE outstanding feature of cut-over land reclamation work during the past year was the utilization of salvaged war explosives for the removal of stumps and stone. The use of these explosives has resulted in many thousands of acres reclaimed in the newer districts of the states having cut-over land problems. It has also made possible more efficient and more economical operation of many thousands of farms which have been in operation many years but which, for some reason or other, have either inadequate acreage or acreage badly cut up with occasional stumps and stones.

Picric acid has been the explosive available during the year from July 1, 1922 to July 1, 1923. This picric acid has been distributed by the division of agricultural engineering of the U. S. Bureau of Public Roads in cooperation with agricultural colleges of the various states at cost of preparation and distribution. A total of 4,179,550 pounds was distributed to twenty different states according to data furnished by Mr. S. H. McCrory, chief of the U. S. D. A. division of agricultural engineering. A conservative estimate of the saving made possible by this distribution is placed at $500,000. This is a tangible result of an engineering project worked out by the agricultural engineers. The investigations which made possible the utilization of picric acid, the method of preparation and use as well as the final distribution to the farmers themselves were carried on by agricultural engineers. All were made by the U. S. D. A. Division of Agricultural Engineering cooperating with the University of Wisconsin and the U. S. Bureau of Mines. The following table shows the quantities used by various states. Wisconsin, Michigan and Minnesota lead in the consumption of this explosive among the various states with a total of over three and a half million pounds.

Picric Acid Distributed for Agricultural Purposes by States During the Year, July 1, 1922 to June 30, 1923, by the Division of Agricultural Engineering, Department of Agriculture

States	Pounds	States	Pounds
Alabama	100	Mississippi	18,000
Arizona	1,100	Missouri	25,100
California	18,000	Nebraska	67,000
Connecticut	17,000	North Carolina	107,950
Georgia	40,000	Ohio	20,000
Iowa	82,000	Oklahoma	400
Kentucky	33,000	South Carolina	16,700
Maryland	500	Tennessee	36,200
Michigan	451,300	Vermont	3,200
Minnesota	627,900	Wisconsin	2,614,000
TOTAL	4,179,550 pounds		

Sodatol—A New War Explosive

The supply of picric acid was exhausted early last year. This past year investigations were conducted by the U. S. D. A. Division of Agricultural Engineering, the University of Wisconsin, and the U. S. Bureau of Mines to work out uses for supplies of TNT and sodium nitrate still available from war surplus. Sodatol is the result of this investigational work which was carried on for several months under both field and laboratory conditions, and which determined not only its usability but determined methods of preparation and the mixture required. From these tests, specifications were written and bids opened to the public for cartridging, preparation, and shipment under a distribution scheme along the same general lines as that followed in the handling of picric acid. The very low price obtained for the cartridging contract by the Division of Agricultural Engineering is a definite agricultural engineering contribution.

Sodatol is a high explosive prepared by mixing TNT (tri nitrotoluol) and nitrate of soda. Both TNT and nitrate of soda are thoroughly dried before cartridging. The nitrate of soda is ground to a fineness such that it will pass through a 20-mesh screen and not over twenty per cent passing through a 100-mesh screen. The mixture is very thoroughly compounded so as to insure uniformity in execution. Tests proved that 45 per cent TNT and 55 per cent of sodium nitrate was a satisfactory mixture.

The resulting mixture is more sensitive than TNT or picric acid although less sensitive than nitro-glycerin dynamite. It is an entirely safe explosive. It may be handled with ordinary care used in handling high explosives. It will burn without explosion in small quantities.

It is detonated with an ordinary No. 6 blasting cap or electric blasting cap.

In ordinary open air blasting operations it will not cause headaches or other ill effects. It does not stain the hands as does picric acid under ordinary conditions of use.

*Part of the 1923 report of the Committee on Land Clearing.

(Right) Placing a charge of Sodatol, the new salvaged war explosive, in a white pine stump in Wisconsin. (Above) What the vicinity of the same stump looked like a second after the charge had been fired

Sodatol does not freeze, and it will not deteriorate in storage if kept dry.

It is packed in cartridges 1¼ by 8 inches, the same as ordinary dynamite. These cartridges run about two hundred and forty to the hundred pounds to give a strength approximately equivalent to that of a cartridge of ordinary dynamite. It is therefore about 15 or 20 per cent stronger than ordinary dynamites.

Sodatol probably equals in quickness and shattering effect about 30 or 40 per cent dynamite.

Cartridging for trials was done by hand, using heavy Manila wrapping paper for shells, the shells being paraffin-dipped before filling and the filled cartridge redipped afterward. The finished cartridge weighed approximately 6½ to 7 ounces. Cartridges were 1¼ by 8 inches in sizs. Detonators, both six and eight, were used. Tests of these caps with an aluminum plate cap testing device indicated caps of good quality.

A mixture of one part TNT and one part sodium nitrate was detonated completely with a No. 6 or No. 8 cap after repeated trials. A mixture of three parts TNT and two parts sodium nitrate also gave similar results, this mixture of three-to-two apparently being a very desirable combination of these two substances for this kind of work. Mixture of one part TNT and two parts sodium nitrate failed to detonate with a No. 6 cap or with a No. 8 cap. A two-to-three mixture also failed to detonate. A mixture of four parts TNT with five parts sodium nitrate was detonated completely with a No. 8 cap in some of the trials. At other times this material failed to explode completely, the cap only setting off the material which immediately surrounded it.

This sympathetic sensitive test was conducted in the usual manner, using a paper tube and half cartridges of the explosive at the given distances from each other. With a four-to-five mixture the second piece failed to detonate at one-inch distance, and in some cases the first piece in which the cap was placed failed to detonate completely. With a mixture of one part TNT to one part sodium nitrate, the second piece was detonated at from one to two inches. With a three-to-two mixture, the second piece was detonated sympathetically at three to four inches distance.

Trial	1	2	3	4	5	6
TNT	1	2	4	1	3	2
$NaNO_3$	2	3	5	1	2	1
Detonator No. 6	Inc.	Inc.	Inc.-C	C	C	C
Detonator No. 8	Inc.	Inc.	Inc.-C	C	C	C
Sympathetic distance-inches	0	0	0-1	1-2	3-4	4-5

Inc. = incomplete detonation
C = complete detonation

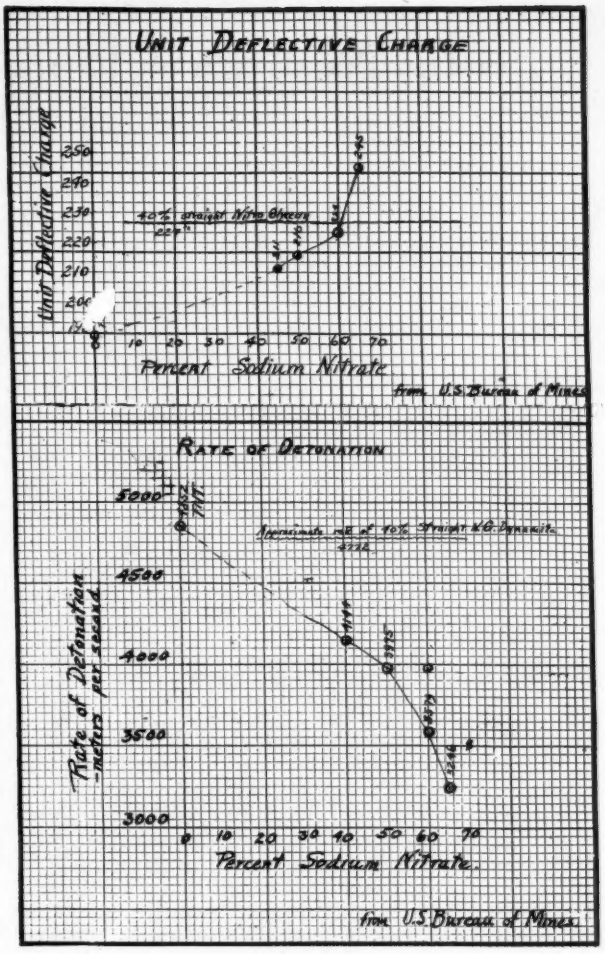
Small quantities of water, one per cent or over, added to a mixture of one part TNT to one part of sodium nitrate reduced its sensitiveness and made detonation incomplete with either a No. 6 or No. 8 cap. On freezing these cartridges, however, it was found that complete detonation occurred with one per cent water with either a No. 6 or No. 8 detonator.

The mixture of TNT and sodium nitrate was ignited with difficulty and burned comparatively slowly. Raw TNT burned approximately twice as fast as the mixture of TNT and sodium nitrate. In no case was the explosive mixture ignited by burning fuse laced through cartridges.

Bullets shot from a 35-calibre Winchester rifle failed to set off a mixture of one TNT to one part sodium nitrate at a distance of fifty feet. Repeated trials with the bullets shot both through the side of the cartridge and through the cartridge end for end failed to cause explosion.

No effect could be noted on a dry mixture of TNT and sodium nitrate by the various temperatures ordinarily encountered. Where the mixture contains small percentages of water, a frozen condition seems to be advantageous to complete detonation.

Both cartridges and the mixed raw material left exposed in the open air failed to absorb appreciable quantities of water, indicating that no difficulty would be met by the hydroscopisity of the material. After a period of about


Unit Deflective Charge
Unit Deflective Charge
Percent Sodium Nitrate
from U.S. Bureau of Mines
Rate of Detonation
Rate of Detonation - meters per second
Percent Sodium Nitrate
from U.S. Bureau of Mines

These two charts show the unit deflective charge and the rate of detonation when mixtures of TNT and sodium nitrate of varying proportions were used in the tests

forty days in the office, cartridges were tested and found to contain a maximum of 0.08 per cent moisture.

Placing paraffined cartridges in a pail of water, it was found that small opening in the cartridge ends permitted the water to saturate the material quickly. The material was about equal in resistance to most ordinary dynamites when actually placed under water. The mixture is not as resistant to moisture as is either raw TNT or picric acid. Care in cartridging will be more essential and loads under stumps must not be left a long time.

In this test the sodatol mixture was exploded in a cannon or mortar which constitutes the weight of a heavy pendulum. The swing of this pendulum caused by the explosion is compared with the swing caused by a standard formula, 40 per cent straight nitro-glycerin dynamite. The "unit deflective charge" is the number of grams of the explosive required to swing the penduum through a distance equal to that caused by 227 grams of the standard 40 per cent nitro-glycerin dynamite.

It will be noted from the chart that TNT with a unit deflective charge of 189 grams is stronger than straight nitro-glycerin dynamite with 227 grams, but that mixtures with nitrate soda cause a rise, gradual at first but rapidly after about 50 per cent nitrate of soda is added.

This test should not be considered alone as an indication of working strength as other factors enter when explosive is handled in the field.

The rate of detonation of an explosive is the rate at which the detonating wave travels through a column of the

(Continued on page 87)

Some New Developments in Land Clearing

By L. F. Livingston

Mem. A. S. A. E. Land Clearing Specialist Michigan Agricultural College

WE consider one of the most important new developments in this work to be an attitude of discrimination. This attitude involves the consideration of land which under existing and probable future conditions should be reclaimed as well as the consideration of lands now in cultivation, which might better be abandoned. This latter group of lands may in the past have been able to compete under the then existing conditions, but cannot now compete under present conditions of high overhead charges for interest, taxes, maintenance and high priced and unreliable labor.

Daniel Webster once stood on a hill in Vermont and talked to 10,000 rural people. Today in the same township there are only 10 farms. The balance of the land has been forced out of production, all due to the poor quality of the land and the scarcity of labor.

In Michigan the annual acreage of land once farmed that is reverting to the state is enormous, thousands of acres every week. The same is true to a more limited extent of the other lake states. Nevertheless, the lake states will import over $50,000,000 worth of feed this winter. The apparent paradox proves beyond a doubt that the land, which is being abandoned, is not producing and that in spite of the high-pressure land clearing methods in use in these states the point of overproduction has not and will not be reached for some time.

A sound reclamation policy resolves itself into the bringing into use of the best available land and a survival of fittest of the land now in production.

In Michigan during the past two years, 100,000 acres of new land with virgin fertility have been cleared. During the same period 150,000 acres have gone back or out of cultivation. At one time this 150,000 acres was probably money making farm land, but with the increased valuation interest, taxes and a 400 per cent increase in labor costs, this land cannot longer be classed as good agricultural land and must be discarded for more productive land. In Northern Wisconsin there are 17,000,000 acres of land. In Southern Wisconsin there are 18,000,000 acres of land; of this 18 million only seven are in production. If one million more is taken out for cities, we have 10,000,000 acres of ilde land in what is considered one of the best dairy districts in the country. Much of this land can and will be forced into a high state of cultivation in the near future.

In the northeast section of the lower peninsula of Michigan a survey was made to determine the amount of cultivated land wherein stumps and rocks remained. The survey covered nine counties. In this area 36 per cent of the cultivated land was inefficient and uneconomically handled because of stumps and rocks. In the nine counties 212,400 acres cost more to cultivate and brought a smaller return than if these tramps were cleared out.

The unsupported opinion of a professional reclamation engineer might naturally and honestly be questioned in the consideration of this problem. The facts here indicated should enable the intelligent man to form his own opinion.

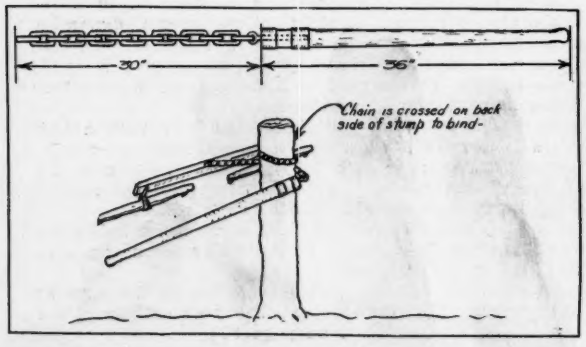
I consider the foregoing remarks as the most important development in land clearing. To go to the other extreme, I will explain a new device that is known as the "chain whip." This is a device to aid in the use of a team for pulling small stumps, consisting of a short length of chain, one end of which is attached to the doubletree on the other end of which is a short handle which is used to snub around a stump and get a quick, strong hitch for pulling. Its use is obvious from the accompanying drawing.

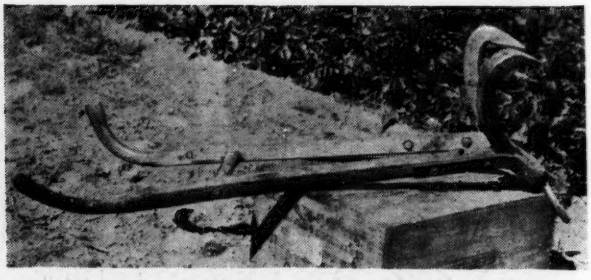
This homemade stump puller is a very simple labor-saving device. It is used in pulling small stumps that would ordinarily be removed with a team and chain. This operation usually consists of placing the chain around the stump and making it fast to the doubletrees, then pulling the stump and unhooking the chain from the stump. This requires more or less time and the driver has to bend his back during the operation. With the chain whip, the back bending is eliminated. The operator drives with the left hand and works the chain whip with the right. The doubletree usually has a grab hook attached. The free end of the chain is attached to the team by this grab hook. The chain is wrapped around the stump so that the chain end of the handle is at the back of the stump. This gives the operator an enormous leverage, and he can hold the chain in place with one hand, even when the team is pulling its utmost. One man with a team and the chain whip can do more work than the same man and team with another man assisting him and using the ordinary type to chain and hook.

A second device developed by the land clearing section at the Michigan Agricultural College is a root hook, the design of which is shown in the accompanying picture. This again is used with a team and man. Its usefulness will be obvious to one familiar with the removal of small grubs and roots in land clearing work.

This root hook is made up of two common swamp hooks and a pair of cultivator handles. A block of steel 3 inches wide is welded between the two hooks with a ring for the chain or cable. The hooks are made of 1½-inch steel. They are about twenty-two inches from the front end of the bend of the point. The points are about four inches long and eleven inches between points.

The effectiveness of this snag hook lies in the angle of the hook and its points. It is so made that when it is set back of a root or stump with the handles in a natural position, the points will dig into the snag and hold with-





Chain whip (left) and root hook (above) developed by the land clearing division of Michigan Agricultural College

out any effort on the part of the operator. In ordinary work a man uses a chain or one swamp hook without a handle. This requires two or three operations and back bending. This hook does away with the necessity of digging around the root for the chain hold, or the stooping and digging with one swamp hook. It is equally effective when used behind a team or tractor, and works particularly well in old hardwood stumps, after blasting, for snagging roots and in pulling small second growth where tops break for the chain. More than double the amount of work under these conditions can be accomplished in the same length of time, and with the same team or tractor than with any of the chains or single-hook methods, and the work is done much more easily.

The Utilization of Salvaged War Explosives in Cut Over Land Reclamation

(Continued from page 85)

explosive. It is measured by specially designed laboratory equipment and expressed in meters per second. The results of this test compared with similar results for known explosives give an idea of the speed or shattering effect of an explosive. Again this data needs to be considered along with results of other tests in the laboratory and field in making conclusions.

It will be noted from the record on the chart of observations that sodatol is slower than TNT alone or than 40 per cent standard nitro-glycerin dynamite. This indicates a more heaving explosive better for stump work but not so shattering for mud capping rocks.

Results in Removing White Pine Stumps in Moist Soil

Stump No.	Diameter inches 1 ft. above ground	Load used -ounces	Soil	Cap	Results
5	30	24 a	Silt loam	6	C
6	49	59 a	Silt loam	6	C
7	33	25 a	Silt loam	6	C
10	34	25 b	Silt loam	6	C
14	49	56 b	Silt loam	6	C
11	38	28 b	Silt loam	6	C
20	33	23 p	Silt loam	6	C
21	40	29 p	Silt loam	6	C
24	18	35 a	Sand	6	C
25	22	49 a	Sand	6	C
30	20	42 a	Sand	6	C
35	21	42 b	Sand	6	C
36	29	77 b	Sand	6	C

a = Sodatol-45% TNT, 55% nitrate of soda
b = Sodatol-55% TNT, 45% nitrate of soda
p = Picric acid
C = Complete removal but not overloaded

The results above indicated show that the mixture of 45 per cent TNT and 55 per cent nitrate of soda is a satisfactory working explosive. The many varying conditions encountered would prevent use of these few selected observations as indications of general results to be expected.

Sodatol being slower than picric acid or high grade dynamites is less efficient for blasting rocks by the mud capping method. Trials showed entirely satisfactory results, however, in breaking boulders found on farms. In no case after at least fifty trials in Wisconsin has failure resulted; for example, on a dark colored so-called "nigger head" boulder of sandstone measuring 48 inches long, 35 inches wide and 23 inches thick, twenty-eight ounces of sodatol (45 per cent TNT and 55 per cent nitrate of soda) with mud cap 9 inches thick, did good work breaking rock in pieces, the largest of which could be easily handled.

Sodatol is too insensitive for so-called propagated ditch blasting. Its use for ditching requires either an electric blasting cap in each charge, or if conditions are favorable a primer of straight nitro-glycerin dynamite may be used with the sodatol. In general, sodatol will not prove as satisfactory a ditching explosive as some others, but its low price will make it usable and economical in many cases.

Sodatol investigations were conducted by: George R. Boyd, division of agricultural engineering, U. S. Bureau of Public Roads; John Swenehart, department of agricultural engineering, University of Wisconsin; W. A. Rowlands, department of agricultural engineering, University of Wisconsin, and members of the staff of the Pittsburgh experiment station of the U. S. Bureau of Mines.

According to the best information available, approximately two to three million pounds will be used by various states this fall of the new explosive, sodatol. The explosive is distributed by the U. S. D. A. Division of Agricultural Engineering, in cooperation with the agricultural colleges in the different states. In most cases the county agent is the local distributing agency. Carload orders are made up in the local community, county or state as the case may be, the federal agency handling the material only in carload lots. Individual orders are taken by the various colleges or county agents.

Distribution of the explosive is being made from cartridging plants at Barksdale, Wisconsin, at 4.07 cents per pound; Ashburn, Missouri, at 4.20 cents per pound; Repauns, New Jersey, at 4.80 cents per pound; Loviers, Colorado, at 5.50 cents per pound; and from DuPont, Washington, at 5.20 cents per pound, in this way serving all parts of the United States. To these prices, freight and expenses are added. The material is delivered to farmers in the various states at prices ranging from six to eight cents per pound, depending mostly on freight charges and the quantity handled in any one place. As a rule, this price is less than one-third of the retail cost of dynamite even under efficient dynamite handling. Dynamite equivalent of one hundred pounds of sodatol retails at from $15 to $40. The higher price is where smaller quantities are handled under wasteful methods of distribution.

It is evident that a very considerable saving is being effected through the distribution of sodatol. It is also worthy of note that in most cases this distribution is made to farmers actually on the land, and is contributing to their individual efficiency by reducing labor cost and rendering equipment more usable and efficient.

COMMITTEE ON LAND CLEARING
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Exposure of Farm Machinery Causes Loss of Dollar an Acre a Year

DETERIORATION of farm machinery because of lack of shelter costs American farmers tens, possibly hundreds of millions of dollars a year, the Research Bureau of the National Lumber Manufacturers Association says. Experts, it says, estimate that avoidable loss occasioned by idle farm machinery standing in open fields is perhaps equal to one-half of all the taxes paid by the farmers of the United States.

If conditions in important farming areas of Illinois reflect the situation the country over, damage to farm machinery from the elements runs up to a most amazing total. Engineers motoring through Illinois recently found that the loss to machinery and implements left standing on farms along the roadside would be $650 per square mile a year, or more than $1 an acre. In a distance of 126 miles they observed 12 tractors, costing $1,000 each, standing exposed to the weather, absolutely without any protection. These tractors, built to give twenty or more years of hard service, probably will be consigned to the junk heap after five years.

There are 369,000,000 acres of land under cultivation in the United States. If the Illinois estimate holds good for the rest of the country, a loss of more than $370,000,000 a year is sustained by the farmers because of lack of proper housing of their farm machinery and implements. This would pay for enough building material to furnish adequate protection for a generation.

Research Methods in Agricultural Engineering

Research activities in the agricultural-engineering field are presented under this heading by the Research Committee. Articles dealing purely with the manipulation of research methods and equipment are featured. Members are invited to discuss material presented and offer suggestions on timely topics

Research Problems in the Design of Tobacco Barns*

By James B. Kelley

Member A. S. A. E. Professor of Agricultural Engineering, University of Kentucky.

IT is the purpose of this paper to discuss a few of the unsolved research problems in the designing of a barn for air curing tobacco, and particularly White Burley tobacco.

According to the 1922 yearbook of the U. S. Department of Agriculture, in that year there were 271,710,000 pounds of Burley tobacco raised in the United States, valued at $67,925,000, and a total production of all kinds of tobacco of 1,324,840,000 pounds, valued at $306,179,000. Some years the growers suffer enormous losses due to houseburn. No accurate information is available to show the losses due to this cause, but, according to the best information available, it is estimated that the amount of Burley tobacco damaged under the present methods of curing varies from 1 to 50 per cent, depending on the seasonal conditions at time of curing. Houseburn may reduce the selling price approximately two-thirds, and in some cases entirely destroy the plant. As this loss can be prevented by better methods of curing, the designing of a better tobacco curing barn is an engineering problem of great economic importance in Kentucky and other tobacco-raising states.

For the benefit of those who have never seen tobacco grown, the following information will give a better perspective of some of the problems involved in the raising and curing of Burley tobacco.

The tobacco growers have learned that the tobacco plant is very sensitive to surroundings and conditions under which it is grown. Its physical characteristics and composition are affected by soil, climate, fertilizers, and the cultural methods of the growers. Climate influences flavor, soil affects texture, and the quality of the cured tobacco depends to a large extent on the skill displayed by the grower in curing it.

No Other Crop Requires More Scientific Knowledge to Grow Than Does Tobacco

Tobacco specialists inform me that no other crop requires more scientific knowledge to grow it than does tobacco. There are a number of scientific problems in connection with the culture, fermentation and curing of tobacco that our tobacco men are just beginning to understand, all of which opens up very interesting research in chemistry, physics, bacteriology, and engineering.

White Burley tobacco was introduced into Kentucky about 1869, and this industry has grown to such an extent that Lexington, Kentucky, the seat of the University of Kentucky, has become one of the outstanding tobacco markets of the world. Since the establishment of the Burley Tobacco Growers' Co-operative Association in 1921, Lexington, which was formerly generally known as the largest loose leaf market in the world, has become the headquarters for the growers' marketing association which controls the sale of a large proportion of the Burley crop.

The growers start to work on this crop as soon as the frost is out of the ground in the spring, and it occupies their attention until it is marketed in the late fall or winter. The tobacco plant beds are prepared during February and March. The soil in the plant beds is sterilized by burning or steaming and the seed is sowed previous to April 1, depending on soil and atmospheric conditions.

About the first of June the plants are ready to be transplanted into the field. They are planted by hand or by tobacco transplanting machines in rows 3½ to 4 feet apart and at intervals of 14 to 24 inches in the rows. Three men with a machine planter can plant about three acres a day. Between planting and harvesting the plants are cultivated, topped, suckered, and poisoned to kill worms. One man can care for about four acres.

Burley Tobacco Is Cured by the Air-Curing Process Which is Really a Ripening Process

When the tobacco is sufficiently ripe it is harvested by splitting the stalk to within a few inches of the ground and cutting off at the ground, or by spearing. The stalks are then hung in inverted position on four-foot sticks, about an inch and a quarter in diameter, and stuck into the ground, where the plants are allowed to wilt. Often the tobacco is hung on a scaffold in the open field to prevent sunburn and to get wilted thoroughly before placing in the barn. After a sufficient amount of wilting takes place, the plants are hauled to the tobacco curing barn and hung on tier rails to cure. The cutting of tobacco takes place during August and September. The curing process takes about two months. After it has cured, it is "bulked" down while in case, after which it is stripped, graded, and tied into hands ready for the market.

Burley tobacco in Kentucky is cured by the air-curing process. After the wilted tobacco is hung in the barns, the curing is controlled by the opening and closing of ventilator doors, placed at intervals on the sides of the barn. Curing is not simply the drying out of the leaf; it involves a number of other important changes in composition which can be brought about only under definite conditions.

The curing process is really a ripening process. The similarity between the curing of tobacco and the ripening of fruit was first pointed out by Dr. J. H. Kastle, late director of the Kentucky experiment station, in an unpublished address in 1914. (Kentucky Experiment Station Bulletin 202.)

According to the following information taken from the U. S. Department of Agriculture Bulletin 143, Bureau of Plant Industry, the curing of tobacco may be divided into two stages.

"The changes take place while the leaf is still alive and depend upon the life activities of the minute cells which make up the body of the leaf. The leaf undergoes a slow process of starvation unless it is killed permanently by injury, such as bruising, by heat, or too rapid drying out. Of course, the leaf must have food in order to remain alive and

* Part of the 1923 report of the Committee on Agricultural Engineering Research.

this comes from the reserve supply which has been stored up.

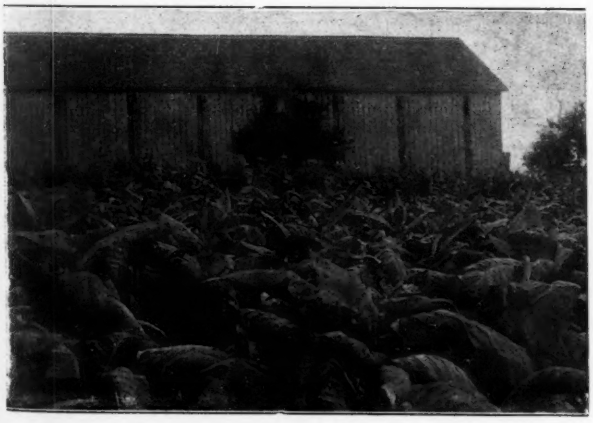
"The ripe leaf is rich in starch, and one of the important changes in curing is the disappearance of this starch, which is consumed by the living part of the leaf. If the leaf is killed there is no means of removing this starch and the tobacco is harsh, lifeless, and strawy. The vitality of the tobacco plant is remarkable and parts of the leaf will continue to live for several weeks in the curing barn under favorable conditions. After the starch is all used up it is probable that some of the nitrogenous constituents are attacked as a last means of prolonging the life of the residual living matter. The life activities of the tobacco plant practically cease below a temperature of 40 degrees Fahrenheit, while they increase as the temperature rises, until at about 125 degrees Fahrenheit the living cells are killed. These activities are also lessened by loss of water and cease as soon as the leaf becomes dry. In practice, the best temperatures for curing lie between the limits 60 and 100 degrees Fahrenheit and the relative humidity should be about 85 per cent. If the humidity becomes much higher, pole sweat will develop on the leaves most advanced in the curing, while if humidity falls much below this figure the leaf will dry out too rapidly.

"Along with these changes in composition the green color is replaced by a yellow color if curing is properly conducted. If the leaf is killed outright by burning or too rapid drying out, the green color cannot be removed by any subsequent treatment, but if the leaf remains alive for two or three days, even though the green color has not fully disappeared, that which remains may be removed by sweating or fermentation. The full development of the yellow color marks the end of the first period of curing."

Injury to the Tobacco From "Pole-Burn" Must Be Guarded Against in the Curing Process

"During the first stage of the curing process the tobacco may be injured by 'pole-burn.' Pole-burn is prevalent during warm, damp, foggy weather. In a few hours the whole crop may be turned to a dark brown, wet, soggy, and easily torn lot of leaves hopelessly damaged." (Reference: "Tobacco Leaf" by Killebrew and Myrick.)

Dr. William C. Sturgis, in describing this disease, says: "It is characterized by the appearance on the surface of the leaf of small blackened areas giving the leaf the aspect of having been sprinkled with some corrosive liquid. These areas increase in size, become confluent and sometimes within thirty-six or at the least forty-eight hours, not only is the whole leaf affected, but the entire contents of the curing barn may be rendered quite worthless as tobacco. Microscopic study revealed in the center of each blackened spot a minute, elevated pustule. Sections through the center of one of those pustules showed that the tissue of the leaf was largely disintegrated and the cells themselves were largely filled with bacteria. They develop rapidly in the tissues of the leaf, raising the epidermis and finally breaking through at one or more points in the blackened area. They spread out in a thin, slimy film, forming a brown, translucent crust of cheesy consistency and composed entirely of bacteria themselves."



This picture shows a standard air-curing Burley tobacco barn which is almost universally used in the White Burley growing section of Kentucky. In the foreground is a field of tobacco growing

In tracing the development of the disease, this author states that at first the surface of the leaf is attacked by a fungus of the genius Cladosporium, related to the leaf-spot disease of the tomato. This does little direct injury, but after some time the leaf is attacked by the bacteria, which swarm into the interior through the breaks made by the Cladosporium, the remains of which are found mingled with bacteria. Of the latter, there are at least two species—one a true bacterium, the other a Streptococcus.

Air and Moisture Are the Two Essentials Needed In Securing the Brown Color in Tobacco

These bacteria develop best between 70 and 90 degrees Fahrenheit, but a temperature of 90 to 110 degrees, or below 35 to 40 degrees checks their development. Furthermore, all attempts to inoculate the cured tobacco with them failed; the crop is in little danger after a period varying from ten to twenty days after the beginning of curing. The remedy suggested is free ventilation and control of moisture and temperature by the aid of artificial heat.

"In the second period the changes do not depend upon life processes, they consist mainly in further breaking up of the products formed in the first stage of curing. One of the most important changes is the development of the brown color. The brown coloring matters are formed by process of oxidation after the leaf cells are dead." (Reference: U. S. Bulletin 143, "Tobacco Leaf," Killebrew & Myrick.)

If the tobacco is hung too closely, preventing the free access of air, the color will change from green to a dark brown and the plant become subject to houseburn.

The two essentials for the development of the correct brown color are a supply of oxygen which is obtained from the air and a sufficient amount of moisture. The chief danger as regards the curing is that the leaf will cure too dark because of excessive moisture.

The amount of coloring matter in the leaf depends chiefly on the conditions as to soil, fertilizers, and climate under which it is grown, and is not under the control of the operator in the curing. The operator can regulate the uniformity of the brown color by controlling the moisture. When the leaves begin to turn brown the relative humidity should be reduced from 80 to 65 or 70 per cent until the stems are dry.

Light should be carefully excluded, especially during the latter stages of curing, as it has an injurious effect upon the color of the leaf.

Before stripping, the tobacco is bulked down when the weather is cool and damp. This causes a fermentation to take place which helps to distribute the color and also puts the tobacco in condition so it can be easily handled by the strippers.

In curing, the tobacco leaf loses about 75 per cent of its green weight and to cure it successfully, this amount of water must be removed at such a rate as will best allow the other important changes to take place.

The length of time required for curing varies from year to year, but if conditions are right, it usually takes six to eight weeks.

The information that is available at present indicates that the following factors affect the successful curing of tobacco, and they should be controlled by the operator:

1. Ripeness of tobacco before it is cut.
2. Prevention of injury to leaves in handling plants.
3. Correct spacing of plants when hung in barn.
4. Correct temperatures in barn for curing.
5. Correct humidity of air in barn.
6. Correct circulation of air.
7. Proper regulation of intensity of light.

Accepting the preceding information on curing as being

correct, the essential requirements of a Burley tobacco curing barn are as follows:

1. Barn should be of ample size to house properly the crop so the plants will not be crowded.

2. The barn should be constructed of timbers of the proper sizes to support the load of the heavy uncured tobacco, and the tobacco hangers while filling barn, and also to withstand wind storms.

3. The barn should have an economical and easily controlled heating and ventilation system for providing the proper conditions of temperature, humidity, light, and circulation of air in the barn during the curing season when the weather conditions are unfavorable.

Through the courtesy of E. J. Kinney, professor of farm crops of the University of Kentucky, a specialist in raising tobacco, the following statements concerning the problem of curing tobacco were furnished.

"Tobacco is cured either by natural means (the practice known as air curing), or by the use of heat. In some cases a combination of air curing and heat curing may be practiced. Cigar tobacco and White Burley tobacco are air cured, and the tobacco trade has become accustomed to expect from these types of tobacco certain definite qualities which can be brought out only by air curing, or by temperatures not much higher than summer temperatures if artificial heat is used. On the other hand, the open fire cured tobaccos which are cured by open wood fires under the tobacco after hanging in the barn, and flue-cured tobaccos which are cured very rapidly by artificial heat, each have certain definite qualities which are recognized as belonging to these types of tobacco, and which can be brought out only by the particular method of curing.

"The problem in air curing then is to devise methods of curing which will obviate the danger of houseburn and, at the same time, give a natural curing. The ideal condition for air curing is a temperature of from 80 to 100 degrees Fahrenheit and a relative humidity of about 85.

"The only way in which houseburn can be prevented under certain weather conditions is by the use of artificial heat. Too high temperatures are not desirable as this would change the quality of the leaf, as in the case of flue-cured tobacco. The temperature should be little or no higher than what might be obtained in very hot summer weather. With this high temperature and a relatively high humidity, curing can proceed as under the best natural conditions and yet give us a leaf identical in character with that where no heat has been used.

"The engineer's problem is to devise a barn so that under favorable weather conditions ventilation may be secured in order that air curing may go forward naturally. The ventilators should be constructed in such a way that the barn can be closed tight and artificial heat applied sufficient to raise the temperature several degrees when the weather becomes unfavorable for curing."

Measurement of Seepage Losses in Canals

(Continued from page 83)

maintained constant at that height. In one instance the water was measured into the pool through a standard submerged orifice, and the rate of flow which maintained the water surface at constant height was noted. There will be opportunity to repeat this experiment, the results of which were somewhat different than that indicated by the rates under a falling water surface. The expedient of pools has been used almost exclusively in the determination of seepage rates from concrete-lined channels. It is, in fact, usually the only one available, as the statement that the "seepage losses are overshadowed by the unavoidable inaccuracies in gaging." applies with special force to the concrete-lined channel.

One of the chief difficulties encountered in an undertaking to determine seepage losses in flowing channels is the derangement due to change of stage of the water. It is found that what will ordinarily pass for a constant stage, or what the casual observer will note as a constant stage, will upon close observation show material changes in the elevation of the water surface in a short time, and especially in the length of time required for a set of gagings to be made or for a change in stage to pass from an upper to a lower gaging section. If unaffected by diversions or other features between the upper and lower gaging sections, any change of stage appears first at the upper section. If the stage is rising, it means more water is coming into than is going out of the portion of the channel under investigation, and if the stage is falling, then, except as reduced by seepage, more is flowing out than in. It is evident, therefore, that in case of a rising stage, unless it is properly accounted for, the seepage rate as determined from discharge measurements will be too great, perhaps several times too great if the change of stage is considerable and the actual rate of seepage small. In case of a falling stage, not taken into account, the computed rate of seepage may be too small, or reduced to practically zero, or the figures may show a gain in the amount of water carried by the channel, even when it is known that there is no possibility of such a gain. The difficulty on this score could be eliminated quite simply if open channel rating curves and water stage recorders were perfect devices, or even nearly so. In spite, however, of the extent to which they fall short of perfection or even of satisfactory performance, they have been used to make possible computations of the amounts of water flowing into and out of a length of channel during a considerable period of time.

The usual purpose of the water stage registers, however, has been to detect changes of stage and to identify corresponding stages at the upper and lower gaging sections.

By way of partial summary the following specifications will be submitted, prescribing conditions which should attend a project for the measurement of seepage from irrigation channels, in order that results may approach the practicable limit of reliability and accuracy:

1. The water cross-section at the upper gaging of a set should be similar in form to that at the lower, the mean velocities should be approximately equal at the two sections, and the range and distribution of the velocities should be about the same in the one case as in the other.

2. In order that "the seepage losses may not be overshadowed by the unavoidable inaccuracies of measurement" the gaging sections should be as far apart as consistent with other considerations, such as the multiplication of diversions, the traversing of widely different soil formations, and the like.

3. Any inflow except at the upper gaging section is objectionable. Any flow except at the lower gaging section is likewise objectionable. It is highly desirable that there shall be no intervening active diversions nor leaks, nor contributions of waste water.

4. The range of velocities should preferably not include those lower than one foot per second nor higher than three feet per second, except in large canals, in which the range may be extended without impairment of accuracy of measurements. As a basis of judgment in the matter, it may be stated that the meter is not so reliable for the lower velocities, and the measurements of depths in swift (turbulent) water is unsatisfactory.

5. Steadiness of stage should be sought. A prime essential to this end is the active cooperation of the canal management and noninterference by irrigators. Complete steadiness is most nearly attained through the agency of equalizing reservoirs of adequate size.

* * *

Most of the outstanding agricultural engineers of the country—from North, East, South and West—will be in attendance at the eighteenth annual meeting of the American Society of Agricultural Engineers to be held at Lincoln, Nebraska, June 18, 19 and 20. All agricultural engineers who attend will be greatly benefited by this contact, which can best be obtained at an A. S. A. E. meeting.

A. S. A. E. and Related Activities

The Annual Meeting Program

PLANS for the program of the eighteenth annual meeting of the American Society of Agricultural Engineers to be held at Lincoln, Nebraska, June 18, 19, and 20, are much farther along than they have been at a corresponding date for any previous meeting of the Society. The Meetings Committee is working hard and making a big effort to outdo even the very successful meeting that was held in Chicago last November. At the present time the indications are that not only will the attendance be larger at Lincoln, but also that an even more instructive and interesting program will be presented at that time.

The section chairmen are arranging with some of the best talent in the country for the presentation of subjects of vital interest to the agricultural engineering profession.

An effort also will be made not to have the program too full, so that there will be time to discuss papers that feature the various section programs.

The indications are that quite a large number of members who are planning to attend the meeting will make the trip by automobile. One group, for example, plans to make the trip a tour of inspection of a number of agricultural-engineering projects that are under way.

As announced in the March issue of AGRICULTURAL ENGINEERING, June 17, the day before the official opening of the Lincoln meeting, has been set aside for committee meetings, round table conferences, excursions, and demonstrations. There will be a reclamation round table and field excursion to look over the work of soil erosion and drainage in the vicinity of Lincoln. The agricultural-engineering staff of the University of Nebraska will put on a tractor testing demonstration, and will also have a number of exhibits.

Undoubtedly other groups will want to hold committee meetings or round table conferences at Lincoln on June 17. Arrangements for such meetings should be made with the Secretary as early as possible.

Committee Reports to Be Condensed

FROM November to June makes a short administrative year and it is possible that the work of a number of committies will not be completed by the time of the Lincoln meeting. In addition to this the Meetings Committee is confronted with the problem of what to select. There is more good material available than can possibly be presented in the three-day meeting. In view of these conditions the section chairmen, who are also members of the Meetings Committee, have agreed that committee reports must be more condensed for presentation on the program than has been the case in the past. In other organizations where committees have three and four meetings per year, the high points of this committee work are presented in ten or fifteen minutes. It is believed that the agricultural engineers can do as well.

It is evident wherever a committee has done a creditable piece of work it should be allowed a place on the program, but it is a serious question from the standpoint of the general policy of the Society if any committee should be allowed to consume one hour going into minute details.

We are making a strenuous effort this year to have committee reports condensed, so come to Lincoln prepared to hear boiled down, digested committeee reports which will give you the main facts in not over fifteen minutes.

Research and Economic Production to be Featured at Lincoln Meeting

THE program for the Lincoln meeting is being built around the two general themes "Research Fundamental to Agricultural Development" and "The Relation of Agricultural Engineering to Economic Production." While teaching and extension work will not be neglected on the College Section program, major attention will be paid to research. This theme will also run through the rural electrification program. R. W. Trullinger of the U. S. D. A. Office of Experiment Stations will present a paper discussing "An Investigation Program for the Application of Electricity to Agriculture."

The program of the Farm Power and Machinery Section will be built almost entirely around ways and means of more economic production in agriculture. The economic aspects of reclamation work will also be featured, while those in charge of the program for the Farm Structure Section are endeavoring to collect all material which will throw any light upon more economic construction and maintenance of farm buildings. Those in charge of developing the program feel that these two general subjects are of major importance at the present time and that the papers to be presented will strike a most responsive note as regards general agricultural development.

Agricultural Engineering Day

ON Saturday, March 1, the entire student body and faculty of the Branch College of Agriculture, University of California, at Davis, worked together on the grounds. There were over three hundred men in their working clothes, some wielding picks, some shovels, some driving tractors, and some building fences. There was a chance for the landscape gardener, for the horticulturist with his pruning shears, for the laborer with pick and shovel and a willing hand, and for the indispensable mechanic.

The outstanding feature of the day was the manner in which the students in agricultural engineering put into practice what they learn in the class room and laboratory. There were five gasoline tractors on the field, one plow, one disk harrow, and several drags. The tractors were driven by students under direct supervision of the agricultural-engineering division and performed jobs that would have been very arduous.

Some thirty trees were pulled over and dragged away. A tamarack hedge several hundred feet long was also removed by an "iron horse." Fencing was stretched, heavy timbers moved from place to place, and, in fact, the tractor was in evidence on all parts of the field. The students seemed to take very readily to this class of work, another indication that the American boy proves that he is being "brought up" on gasoline, by the aptness with which he takes hold of power-farming machinery.

The student in farm mechanics recognizes the importance of sharp tools, sets posts with level or plumb bob, lines and spaces trees with transit and chain, adjusts carburetors so as to get maximum power with least expense, and eases into his load instead of jerking it, when using a tractor.

Not only is the boy who runs the tractor benefitted in such cases, but the hundreds of onlookers see how machinery can be profitably used on many different farm jobs.

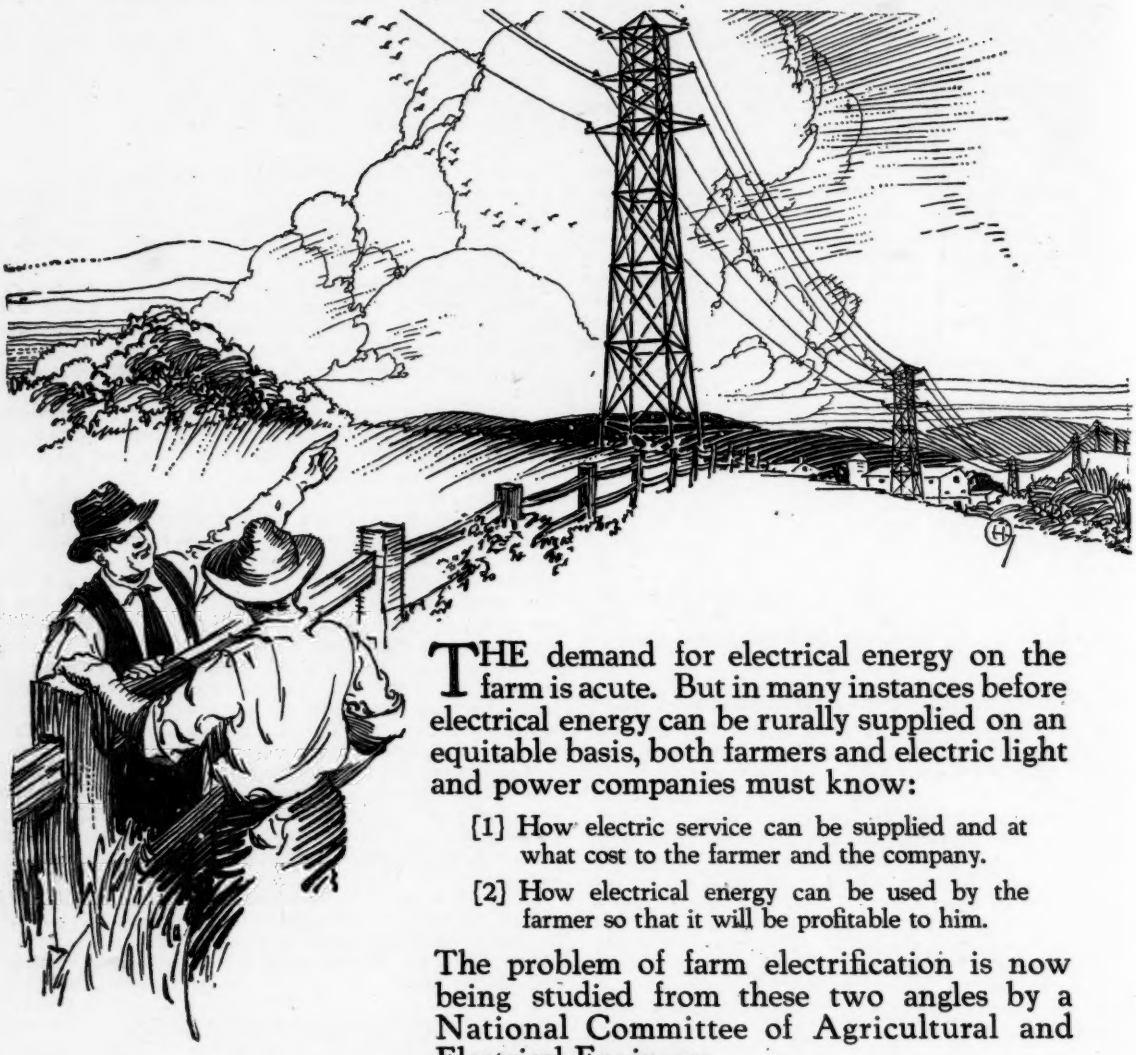
Truly March 1 at University Farm was an "agricultural engineering day."

Openings in Patent Office

EXAMINATIONS for appointments to the examining corps of the U. S. Patent Office are to be held April 9, May 7, June 4, and July 9, 1924. Congress has passed legislation permitting the Patent Office to employ one hundred additional patent examiners for a period of two years. The entrance salary has been fixed by Congress at $1860 a year beginning with July 1, 1924, and promotions are made on a strictly merit system up to $5000 a year. The positions are under civil service and are not political. It is pointed out that the temporary feature of this work should not deter anyone interested in it from taking an examination as the natural turn-over in the Patent Office would more than provide for the absorption of these additional men in case Congress should later fail to enact legislation which will provide for their continued employment. Immediate application should be made to the United States Civil Service Commission, Washington, for admission to these examinations by those who are interested.

(Continued on page 96)

No Stone Will



THE demand for electrical energy on the farm is acute. But in many instances before electrical energy can be rurally supplied on an equitable basis, both farmers and electric light and power companies must know:

[1] How electric service can be supplied and at what cost to the farmer and the company.

[2] How electrical energy can be used by the farmer so that it will be profitable to him.

The problem of farm electrification is now being studied from these two angles by a National Committee of Agricultural and Electrical Engineers.

Investigations must be made of present farm practices. New practices must be suggested—practices made possible by the ease with which electrical energy can be distributed and applied.

NATIONAL ELECTRIC

Be Left Unturned

In accordance with the plan drawn up by the National Committee, these investigations are to be conducted by independent state groups of farmers who will have the cooperation of the country's leading agricultural engineers and of the state agricultural colleges.

In Minnesota fourteen farmers on the Red Wing transmission line are now applying electrical energy and keeping records of energy consumption, time, and labor. They are supervised by the engineers of the Minnesota Agricultural College.

Under the direction of the Alabama Polytechnic Institute, a similar experiment has been started in Alabama. A fact-gathering electrified farm community will be established in each of the leading agricultural sections of the State.

An experimental line has been built in South Dakota. The State College of Agriculture has drawn up an investigation program which the farmers will follow.

Kansas has recently joined the movement.

In other states similar groups are being organized.

Even a foreign survey is being conducted by the United States Department of Commerce to find out what is being done with electricity on European farms.

No stone will be left unturned.

Thus the investigation will include actual farm electrification in ultimately as many as ten or a dozen states and a survey of farm electrical practice all over the civilized world.

This is the most comprehensive, practical task ever undertaken by agricultural and electrical engineers and economists. When it is completed, farming will receive an impetus perhaps even greater than that imparted by the introduction of mechanical tilling and harvesting implements. For the result will not be simply more efficient, more economical farming, with a greater return for time and labor expended, but home and working conditions comparable with those of the city, and the richer life that comes with contentment.

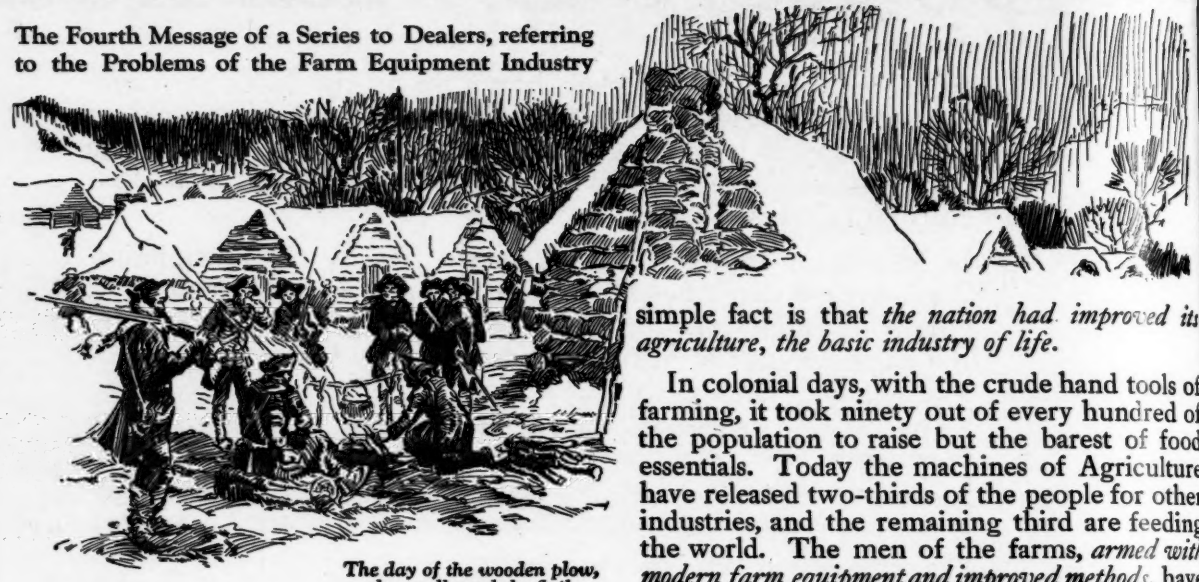
The National Committee in charge of the work is composed of economists and engineers representing the American Farm Bureau Federation, the Department of Agriculture, the Department of the Interior, the Department of Commerce, the American Society of Agricultural Engineers, the Power Farming Association of America and the National Electric Light Association.

A booklet on the work of rural electrification has been published by the National Committee. Read it and pass it along to your neighbor. It will be sent free of charge. Write for it either to Dr. E. A. White, care of the American Farm Bureau Federation, 58 East Washington Street, Chicago, Ill., or the National Electric Light Association, at 29 West 39th Street, New York City.

LIGHT ASSOCIATION

America Owes Much to the

The Fourth Message of a Series to Dealers, referring to the Problems of the Farm Equipment Industry



The day of the wooden plow, the cradle and the flail

DURING the winter of 1778, when General Washington was in command of the first army of American independence, the little band of patriots nearly starved to death at Valley Forge. Only 10,000 men, and the colonists could hardly feed them!

Yet the great American army of 1918 did not know the smallest fear of hunger. Here were four million soldiers, two million of them on foreign soil 3,000 miles away, and America could feed them and nearly all the other armies, too. Besides, she could man the industries which turned out the greatest quantity of manufactured supplies ever produced in a like period of time.

Something had wrought a wonderful change in the power of the nation. It had not been done by skyscrapers, or railroads, or electricity. It was something deeper and more elemental. The simple fact is that *the nation had improved its agriculture, the basic industry of life.*

In colonial days, with the crude hand tools of farming, it took ninety out of every hundred of the population to raise but the barest of food essentials. Today the machines of Agriculture have released two-thirds of the people for other industries, and the remaining third are feeding the world. The men of the farms, *armed with modern farm equipment and improved methods*, have made an endless wilderness to bloom with a vast, never-ending yield.

Wherever modern labor-saving farm equipment is in general use, there you will find also the benefits of civilization — cities, industries, modern improvements, education and contentment. Take away modern farm equipment and you have primitive life, ignorance, poverty and famine.

That is why no industry stands ahead of the farm equipment industry in service to the nation

IN the building of farm equipment the manufacturers have always sought to lighten the burdens of the farmer, to shorten the time required for a given operation, and to increase crop yield. Length of service is another important factor. Twenty to twenty-five years of life in the hardest kind of work, under the widest variety of unfavorable conditions, is not exceptional in farm equipment—it is what the farmer expects.

The industry has always built for rugged strength and utmost simplicity, providing adjustments for varying conditions and supporting all with an extraordinary service of repairs. It has been ready with repairs for every machine and implement, no matter how old. Having sprung from the farm and grown up with farming, the industry has worked in intimate relationship with the problems of field and farmstead. Down

Farm Equipment Industry

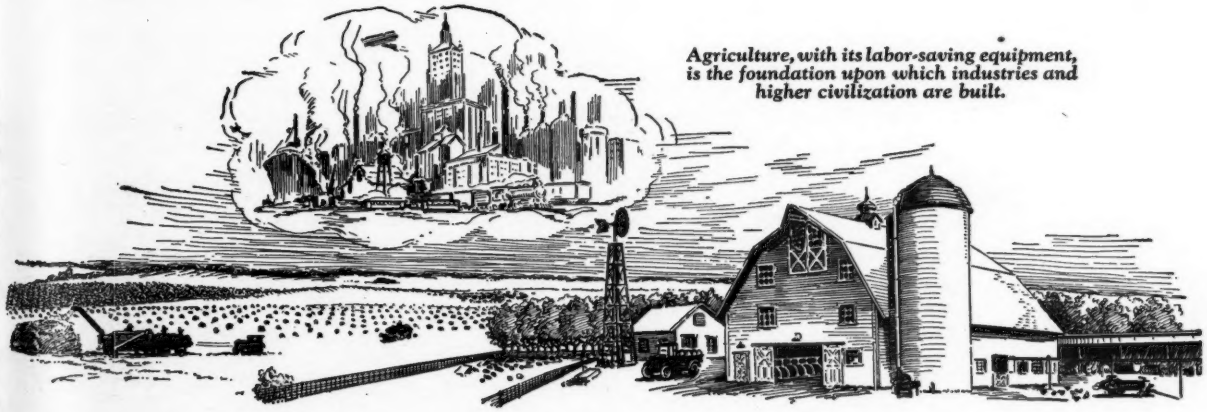
to the present day the tie between field and factory is exceedingly close-coupled.

Of late years the era of mechanical power has come into farming. Tractor and engine power has been linked with field and belt machines, adding tremendously to the producing capacity of men, machines and land. The part played by machines in agriculture today is too great to be fully realized. They are conquering obstacles which appeared unsurmountable twenty years ago, and they are at the same time helping our farmers support an increased population of thirty million more Americans. The stamina that is built into farm equipment—*coupled with the ever-ready service of the farm equipment dealers*—has kept agriculture abreast with the tide.

During the advance of efficient farming, it has been absolutely necessary that liberal service be furnished by men who knew the machines. *Service as rendered with farm equipment sales has a very positive, definite, cash value from the farmer's point of view and should be so considered by him.* To begin with, he pays less money, pound for pound, for the machines that do his work than he pays for any other similar manufactured article he buys. Yet, on top of this great advantage in favor of his farm equipment investment, he receives a service of more use and value to him than he will find among all the other lines with which he is familiar.

This cooperation has lately been rendered in more than full measure. Not content with supplying new equipment to the farmer at lowest prices, the farm equipment dealer has rendered such alert, useful repair service to his customers *that they have been able to tide over the last few years by using old machines restored by repairs and farm equipment service.*

As these words are being read the farm equipment industry is mobilizing a tremendous campaign to help six million farmers make 1924 a successful farming year. Farm operating equipment, embodying the latest improvements for conserving labor and time and increasing yield, is being shipped to dealers everywhere so as to be ready when needed. Thirty thousand dealers are quietly laying in a carefully selected variety of spare parts, totaling for the entire nation a value of thirty million dollars, to take care of old machines that can still be made to work efficiently. These machines, repairs stocks, and facilities for expert, rapid handling during the rush of the harvest season are being made ready many months in advance. Every machine brings with it power for creating agricultural wealth—every repairs stock carries a potential saving of hundreds of dollars for farmers in need of emergency service. *This is a vital work of great magnitude, yet it is but a part of the everyday service the farmer has learned to depend upon from the industry.*



Agriculture, with its labor-saving equipment, is the foundation upon which industries and higher civilization are built.

Research Department

National Association of Farm Equipment Manufacturers

608 So. Dearborn Street, Chicago, Ill.

21-'24

The earliest examination possible should be taken, since those who take these examinations and fail will have an opportunity to take a later examination.

Civil Service Examination

Junior Engineer

THE U. S. Civil Service Commission announces an open competitive examination for junior engineer on May 7, 1924. Vacancies will be filled from this examination in the following and other branches of the service: Bureau of Standards, Bureau of Mines, Bureau of Chemistry, Navy Department, Reclamation Service, Water Resources Branch, National Advisory Committee on Aeronautics, Bureau of Public Roads, Forest Products Laboratory, and Signal Service at Large. The entrance salary for positions in the departments and offices in the District of Columbia will be $1860. The duties of these positions require that appointees perform such work as routine testing, inspection of engineering material, drawing up plans for minor projects, preparing specifications for engineering material or apparatus, performing field work, making computations, preparing maps, assisting in the conduct of experimental research tests, compiling reports, handling technical correspondence, and other related work. Applicants should apply for Form No. 2415, stating the title of examination desired, to the Civil Service Commission, Washington, D. C., or Secretary of United States Civil Service Board at any place listed thereon.

A Correction

IN an editorial, entitled "Farmer's Interest in Machinery," on page 42 of the February issue of AGRICULTURAL ENGINEERING it was stated that Prof. G. W. McCuen was in charge of farm power and machinery work at Ohio State University. Prof. McCuen is in charge of farm power and belt machinery, and Prof. Reed is in charge of farm field machinery, which includes both horse and tractor drawn implements.

Personals

George R. Boyd, senior drainage engineer, division of agricultural engineering, U. S. Department of Agriculture, is author of a report entitled "Extension Work in Agricultural Engineering, 1922," which has just been issued by the U. S. D. A. as Department Circular No. 270.

G. B. Gunlogson, formerly advertising manager of the J. I. Case Threshing Machine Company, has been appointed sales manager of the Case motor car division. The purpose of this change, which is a promotion for Mr. Gunlogson, is to intensify an improved sales effort on Case motor cars.

L. J. Smith, professor of agricultural engineering, State College of Washington, is the author of two popular bulletins just issued by that institution, No. 123, entitled "Plan for Small Barns," and No. 124, entitled "An Economical Farm Level."

W. K. Winterhalter, consulting agriculturalist, writes from Copenhagen, Denmark, that he is making a survey of agricultural conditions in the countries of north Europe and of the possibilities of encouraging emigration of good farmers to the United States.

F. A. Wirt, editor of "Case Eagle," published by the J. I. Case Threshing Machine Company, has been promoted to the position of sales promotion manager. He will continue to edit the "Case Eagle."

Members' Exchange

FOR SALE: One new Keuffle & Esser blueprint frame 36 by 48 inches. Catalog No. 2463-L. Never been used. Write Agricultural Engineering Department, Experiment Station, Lexington, Kentucky, for further information.

Directory of Professional Agricultural Engineers

CLARK E. JACOBY ENGINEERING COMPANY
Consulting Engineers
Drainage, Land Reclamation, River and Flood Control, Tiling, Topographic Surveys, Bridges and Reinforced Concrete Structures
Interstate Building, Kansas City, Missouri

STANLEY F. MORSE
Mem. A. S. A. E. Consulting Agricultural Engineer
GEO. M. ROMMEL, Consulting Livestock Specialist
E. W. MITCHELL, Consulting Horticulturist
Farm inspections, plans, supervision
MORSE AGRICULTURAL SERVICE
132 Frant St., New York City

HARVEY R. BURR
Consulting Agricultural Engineer
Formerly director of agriculture at Williamson Trade School, Pennsylvania
Landscape Gardening—Farm Buildings—Canning Factories
Soils—Livestock—Farm Machinery—Water Power
Marketing—Farm Management
Waunakee, Dane County, Wisconsin

KURT GRUNWALD
Consulting Agricultural Engineer
Investigations and reports covering crop adaptability in arid and humid regions, potential sugar beet production, irrigation and drainage problems, appraisals on land, supervision of farms and ranches, and selection of livestock breeds.
Medford, Long Island, New York

A. S. A. E. Employment Service

This service, conducted by the American Society of Agricultural Engineers, appears regularly in each issue of Agricultural Engineering. Members of the Society in good standing will be listed in the published notices of the "Men Available" section. Nonmembers as well as members, are privileged to use the "Positions Available" section. Copy for notices should be in the Secretary's hands by the 20th of the month preceding date of issue. The form of notice should be such that the initial words indicate the classification. No charge will be made for this service.

MECHANICAL AND ELECTRICAL ENGINEER, graduate of Cornell University and Armour Institute, with nineteen years of practical experience in designing, manufacturing, and marketing gasoline engines, automobiles, motor trucks, and tractors, having specialized particularly on internal-combustion motors and their application, prefers mechanical work cooperating with the different manufacturing and sales departments along the lines of sales engineering. or other work into which his qualifications would fit. MA104

AGRICULTURAL ENGINEER, student for four years at Institute of Civil Engineers, Moscow, Russia, and graduate of the Engineering Faculty of Petrowska Agricultural Academy, Moscow, wants position in irrigation work either in connection with surveys and projects or building irrigation works. Previous experience: Survey and hydrometrical measurements of rivers in Russia, occupying positions up to chief survey; organization for irrigation of Turkestan; during World War worked with engineering corps building bridges and roads, occupying position of assistant to chief of district; public service with water department of the Ministry of Agriculture of Bulgaria, including surveys of rivers and survey of irrigation and utilization of water power; instructor of surveying section of vocational school at Y. M. C. A., Sofia, at the same time giving lectures on agricultural machines and implements to chauffeurs and instructors at the tractor school. Age 34 years. Is now permanently located in United States. MA-120.